FIFTEENTH ANNUAL REPORT

OF THE

Quebec Society for the Protection of Plants

1922-1923

Supplement to the report of the Minister of Agriculture

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QUEBEC

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To the Honourable J. E. CARON,

Minister of Agriculture

Quebec.

Sir:—

I have the honour to present herewith the fifteenth Annual Report of the Quebec Society for the Protection of Plants, containing the proceedings of the meetings of the Society, which were held at Macdonald College, Ste. Anne de Bellevue, Que., on December 7 and 8th, 1922, and March 15th, 1923.

Included are the papers that were read, and the reports of the officers of the Society.

I have the honour to be,

Sir,

Your obedient servant,

B. T. DICKSON,

Secretary-Treasurer.

Macdonald College, Quebec.

QUEBEC SOCIETY FOR THE PROTECTION OF PLANTS

OFFICERS FOR 1922-1923

President—Professor W. Lochhead, Macdonald College.

Vice-President—Rev. Father Leopold, Oka Agricultural Institute, La Trappe, Que.

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G. Maheux, Esq., Provincial Entomologist, Quebec.
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Delegate to the Royal Society of Canada—Prof. W. Lochhead, Macdonald College.

Delegates to the Ontario Entomological Society—Prof. Lochhead and Rev. Fr. Leopold.

Delegates to the Canadian Branch of the American Phytopathological Society, Dr. B. T. Dickson and Prof. G. R. Cosette.

LIST OF MEMBERS 1922-23

Armstrong, Tom	Macdonald College
Adams, John	C. E. F., Dept. of Agr., Ottawa.
Baillairgé, V.	Forest Service, Quebec.
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Barwick, E. C.	37 St. Antoine St., Montreal.
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Blair, W. Saxby	Kentville, N. S.
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Bunting, Prof. T. G.	Macdonald College.
Caron, Omer	Dept. of Agriculture, Quebec.
Chagnon, G.	P. O. Box 521, Montreal.
Charron, Dr. A. T.	St. Hyacinthe, Que.
Clayson, G. H.	17 Charron St., Montreal.
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Coderre, J. A.	Forest Products Laboratory, Montreal.
Corcoran, J. A., M. D.	8, 36th Avenue, Lachine, Que.
Cossette, Prof. G. R.	La Trappe, Que.
Cummings, R. F.	330 First Avenue, Maisonneuve.
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Davis, M. W.	777 Shuter St., Montreal.
Dickson, Dr. B. T.	Macdonald College.
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Drayton, F. L.	C. E. F., Dept. of Agriculture, Ottawa.
Dunlop, G. C.	422 Mackay St., Montreal.
DuPorte, Dr. E. M.	Macdonald College.
Dustan, A.	Wolfville, N. S.
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Fraser, Prof. W. P.	Saskatoon, Sask.
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Gorham, A. C.	Fredericton, N. B.
Gosselin, Alfred	Ste. Anne de la Pocatière.
Gosselin, Charles	Fort Coulonge, Que.
Gousie, Rev. Prof.	St. Mary's College, Montreal.
Gregoire, M. L.	Forest Service, Quebec.
Guenette, L.	Forest Service, Quebec.
Gussow, H. T.	C. E. F., Dept. of Agriculture, Ottawa.
Hale, J. D.	Forest Products Laboratory, Montreal.
Hall, G. H.	672 Durocher St., Montreal.
Hall, Landon	Cowansville, Que.
Hammond, G. H.	Macdonald College.
Hetherington, S. J.	Dept. of Agriculture, Edmonton, Alberta.
Hockey, J. F.	Lab. of Plant Pathology, St. Catharines, Ont.
Honoré, Rev. Father	La Trappe, Que.
Howitt, M. H.	Macdonald College.
Hutchings, C. B.	Entomological Branch, Dept. of Agric., Ottawa.
Gordon, W. L.	Macdonald College.
Jack, Norman E.	Chateauguay Basin, Que.
Jackson, F. Slater, M. D.	108 Park Ave., Montreal.
Jenkins, M. H.	Ottawa, Ont.
Keating, Rev. Prof.	Loyola College, Montreal.

Kieffer, H. F.	Forest Service, Quebec.
Lachaine, O. W.	Macdonald College.
Lavoie, J. H.	Horticultural Bureau, Quebec.
Leopold, Rev. Father	La Trappe, Que.
Levasseur, Rev. Paul	Ste. Anne de la Pocatière.
Lloyd, Prof. F. E.	McGill University, Montreal.
Lochhead, Prof. W.	Macdonald College.
Lods, E. A.	Macdonald College.
Macaulay, R. R.	Ste. Anne de Bellevue.
MacCallum, A. W.	C. E. F., Dept. of Agriculture, Ottawa.
MacClement, Dr. W. T.	Queen's University, Kingston, Ont.
Maheux, G.	Provincial Entomologist, Quebec.
Major, T. G.	Tobacco Division, Dept. of Agriculture, Ottawa.
McLennan, A. H.	Ontario Agriculture College, Guelph, Ont.
McMahon, E. A.	John Cowan Chemical Co., Montreal.
McOuat, J. E.	Macdonald College.
McRostie, Dr. G. P.	C. E. F., Ottawa.
Menard, J. H.	Forestry School, Berthierville.
Milne, A. R.	D. S. C. R., Ste. Catharines, Ont.
Moore, G. A.	159 Querbes Ave., Outremont.
Nagant, H.	64 Maple Ave., Quebec.
Newton, Miss Dorothy	Manitoba Univ. Winnipeg.
Nolet, Louis	College de Lévis, Lévis, Que.
Pasquet, Jos.	Ste. Anne de la Pocatière.
Perry, Miss M.	Macdonald College.
Petch, C. E.	Hemmingford, Que.
Petraz, Mr.	Horticultural Service, Quebec.
Piché, G. C.	Chief Forester, Quebec.
Reid, Peter	Châteauguay Basin, Que.
Raymond, L. C.	Macdonald College.
Raynaud, Mr.	Berthierville, Que.
Richardson, J. K.	Macdonald College.
Roy, H. B.	Sudbury, Ont.
Saunders, L. G.	Cambridge University, Cambridge, Eng.
Savoie, F. N.	Dept. of Agriculture, Quebec.
Simard, J.	Dept. of Agriculture, Quebec.
Simmons, P. M.	Lab. of Plant Pat., Saskatoon, Sask.
Smith, R. H.	Macdonald College.
Southee, G. A.	356 Durocher St., Outremont.
Spittall, J. R.	Annapolis, N. S.
Stanford, Miss P. Clayton	Dartmouth, N. S.
Stevenson, J. N.	Gardenvale, Que.
Stewart, K.	Macdonald College.
Stohr, Rev. L. M.	Ironside, Que.
Strickland, E. H.	Edmonton, Alberta.
Summerby, Prof. R.	Macdonald College.
Swaine, Dr. J. M.	Entomological Branch, Dept. of Agric., Ottawa.
Tawse, W. J.	Macdonald College.
Tessier, G.	Forest Service, Quebec.
Treherne, R. C.	Entomological Branch, Ottawa.
Victorin, Rev. Bro.	University of Montreal, Montreal.
Willey, Dr. A.	58 Metcalfe St., Montreal.
Winn, A. F.	32 Springfield Ave., Westmount.

HONORARY MEMBERS

James W. Robertson, Esq., LL.D., C.M.G., Ottawa.
Hon. J. E. Caron, M.P.P., Minister of Agriculture, Quebec.
F. C. Harrison, D.Sc., Macdonald College.
Rev. Father Superior, Dom Pacome Gaboury, La Trappe, Que.
Auguste Dupuis, Village des Aulnaies.
Canon V. A. Huard, D.Sc., Quebec.
Rev. Father Superior, Ste. Anne de la Pocatière.
J. C. Chapais, D.Sc., St. Denis-en-bas, Que.
A. Gibson, Esq., Dominion Entomologist, Ottawa.
Hon. Minister of Crown Lands and Forests, Quebec.

FINANCIAL STATEMENT

Receipts.

Brought forward. .	135.80	
Provincial Government Grant	250.00	
Interest on deposit	5.19	
		$ 390.99

Disbursements.

Lecturers	$ 74.22	
Delegate to Ontario Entom. Soc	20.00	
Delegate to Royal Society	15.00	
Secretary	50.00	
Postage and Typewriting	25.43	
General Expenses of meeting	14.10	
Printing	8.51	
Balance on hand April 14th, 1923	183.73	
		390.99

Auditor:
E. MELVILLE DUPORTE.

W. LOCHHEAD,
President.

B. T. DICKSON,
Secretary-Treasurer

NOTES: Since the Canadian Phytopath. meeting was held at Macdonald College, there were no delegates expenses therefor.

Only one delegate was able to attend the Ont. Entom. Soc.

REPORT OF THE MEETINGS.

Summer Meeting.

The Summer Meeting was postponed and held on December 7 and 8th, in conjunction with the Annual Meeting of the Canadian Branch of the American Phytopathological Society, which met at Macdonald College. The joint meetings were well attended among those present being Dr. F. C. Harrison, Prof. Wm. Lochhead, Prof. W. P. Fraser, Dr. B. T. Dickson, Dr. R. E. Stone, Dr. J. H. Faull, Prof. F. E. Lloyd, Dr. M. T. Cook, Dr. E. M. Duporte, Dr. W. T. MacClement, Prof. Georges Maheux, Prof. T. G. Bunting, Prof. R. Summerby, Dr. A. MacTaggart, Dr. E. G. Hood, Mr. C. Petch, Miss D. Newton, Mr. Omer Caron, Mr. W. Tawse, Mr. J. G. Coulson, Mr. L. C. Raymond, Mr. F. L. Drayton, Mr. G. C. Cunningham, Mr. J. F. Hockey, Mr. McCurry, Mr. T. G. Major, Mr. R. J. Blair, Mr. J. D. Hale, Mr. Coderre, Mr. Vanterpool, Mr. Atwell, Mr. Baker, Mr. Armstrong, Mr. Spittall, Mr. Gibson.

On the evening of December 7th, a combined meeting of the Quebec Society for the Protection of Plants, Quebec Pomological Society and the Canadian Branch of the American Phytopathological Society was held with Prof. Wm Lochhead in the chair. At this meeting, about a hundred were present and enjoyed addresses from Dr. Melville T. Cook, of the State University of New Jersey, the guest of our Society, and Mr. G. E. McIntosh, the Dominion Fruit Commissioner.

At the business meeting of the Canadian Branch, the following officers were elected:

President, Prof. W. P. Fraser.
Vice Pres., Dr B. T. Dickson.
Sec.-Treas., Dr R. E. Stone.
Councillors, Dr. W. T. MacClement.
Mr. G. C. Cunningham.

The program is given below.

PROGRAMME

THURSDAY DEC. 7th.

Morning session.

10-12 Registration and accommodation.

After-noon Session.

2 P. M. Address. Prof. W. Lochhead (Pres. Q. S. P. P.).

La campagne contre les sauterelles dans Québec en 1922.....G. Maheux.
Plant diseases of western Quebec in 1922.....B. T. Dickson.
The natural control of the Green Apple Bug by a new species of Empusa.....A. G. Dustan.

Control of the Onion maggot in 1922.....W. J. Tawse.
The Dominion Entomological Service.....A. Gibson.
Désinfection et parcelles.....O. Caron.
The pollination of certain vegetable plants by insects.....Mr. Treherne.
Wood v. Fungi (Demonstration slides).....R. J. Blair and J. D. Hale.

Evening session.

7.30 P. M. Welcome. Principal F. C. Harrison.

Address by Dominion Fruit Commissioner.....G. E. McIntosh.
The Past and Future of Plant Pathology.....Dr. Melville T. Cook, State Univ. of New Jersey.

Informal meeting.

Morning session.

Friday Dec. 8th.

9 A. M. Business meeting.

Resolutions, appointments of committees and officers.
Report on the plant disease survey.....F. L. Drayton.
Cultural characteristics of certain root-rot FusariaT. G. Major.
The present statuts of the White Pine Blister Rust in Canada.....A. W. McCallum.

Afternoon session.

2 P. M.

Red Branch of Conifers.....J. H. Faull.
Two plant diseases new to Ontario.....J. E. Howitt.
Control of Oat Smut.....B. T. Dickson, R. Summerby and J. G. Coulson.
Five years' experiments in the control of Oat SmutJ. E. Howitt and R. E. Stone
Control of Raspberry mosaic.....J. F. Hockey.
Balsam rusts.....H. P. Bell and J. H. Faull.
Peony diseases.....J. G. Coulson.
Pea root-rot and wilt of Canning peas.....R. E. Stone.
Distribution of Ribes and Cronartium ribicola in Ontario.....G. H. Duff.
Soft rot of Iris.....J. K. Richardson.
Blue-stem of the Black raspberry.....J. F. Hockey.
Plant pathology in public schools.....W. A. McCubbin.
Smut control experiments with copper carbonate dust and other substances.....W. P. Fraser and P. M. Simmonds.
Stem rust (P. Graminis) on grasses in western Canada.....W. P. Fraser.

ANNUAL MEETING.

The fifteenth annual meeting of the Quebec Society was held in the Biology Building of Macdonald College, on March 15th, 1923. In view of the fact that the Society had already had a meeting in December, the session occupied only the afternoon. There was a good turn out of members with Prof. L. Caesar of the Ontario Agricultural College, Mr. G. E. Sanders, of the Deloro Chemical Company, and Mr. A. Gibson, the Dominion Entomologist, as the chief speakers.

The business meeting opened at 2 p. m.
The minutes of the last meeting were approved.
The report of the treasurer was read and accepted.
The following were the officers appointed for the following year:—

President:—Prof. W. Lochhead, Macdonald College.
Vice-Président:—Rev. Fr. Leopold, La Trappe.
Secretary-treasurer:—Dr. B. T. Dickson, Macdonald College.
Directors:—C. E. Petch, Esq., Hemmingford, Que.
Prof, G. R. Cossette, La Trappe.
A. F. Winn, Esq., Montreal.
Prof. Bro. Victorin, Univ. of Montreal.
G. Maheux, Esq., Provincial Enthomologist, Que.
G. Chagnon, Esq., Montreal.
G. Bouchard, M. P., Ste-Anne-de-la-Pocatière.
Dr. A. T. Charron, St-Hyacinthe.
Auditor:—Dr. E. Melville Duporte, Macdonald College.
Delegate to the Royal Society of Canada:—Prof. W. Lochhead.
Delegates to the Ontario Entomological Society:—Prof. W. Lochhead, Rev. Fr. Leopold and Dr. E. M. Duporte.
Delegates to the Canadian Branch of the American Phytopathological Society:—Dr. B. T. Dickson and Prof. Cossette, Mr. O. Caron and Mr. J. G. Coulson.

It was resolved that the Society, so far as funds are available, continue to help in aiding investigations concerning economic diseases caused by insects, fungi, or bacteria.

The place and time of a summer meeting was left to the discretion of the Executive.

The general session followed and the papers of both meetings pertaining to our Society are given in the succeeding pages.

THE PROTECTION OF PLANTS.

By Prof. W. Lochhead, Macdonald Collège.

In this first joint meeting of the Canadian Phytopathological society and the Quebec Society for the Protection of Plants, I may be permitted to say a few words, first, with regard to some Canadian pioneer botanists and entomologists who "blazed the trail" and made it possible for us to meet here to-day as plant-protection societies; and second, with regard to the special nature of the task of phytopathologists and economic entomologists.

Botany as a distinct department of Canadian University instruction has been late in coming into its own. This was largely due to the fact that Botany for many years was considered of importance only in so far as it related itself to medicine. Queen's University was perhaps the first to appoint a Professor of Botany, but Dr. Fowler had practically no assistance. I can recall the appointment of Prof. Penhallow to the chair of Botany in McGill University in 1883. Prior to that time the instruction in Botany was very meagre, and was done as a subsidiary enterprise by some member of a stronger Natural History Department. In the University of Toronto, Botany was linked up with Zoology, and did not function as a separate Department until some years later.

These were the days of the systematist and the morphologist. Histology had been introduced from Europe by some of the newer workers and its effect was to broaden and deepen Morphology. Physiology had not reached the status of a separate sub-division, and little or no experimentation was done. Mycology was in its infancy and the fungi as a group were given but little attention.

As might be expected, then, our pioneer botanists were systematists, but confining their attention mainly to the flowering plants. To their efforts we are indebted for the fairly complete list of Canadian plants and their distribution. Dr. John Macoun was an indefatigable collector, and his position as Botanist of the Geological Survey enabled him to travel extensively in all the provinces. His collections form the basis of the National Herbarium at Ottawa.

Another man who had an important influence on Canadian Botany was Dr. James Fletcher of Ottawa, Dominion Entomologist and Botanist. Althouh his interests were mostly with insects, yet he devoted much time to the ecological study of plants. His knowledge of plants was of a macroscopic nature, and he was practically unacquainted with the newer phases of Botany, such as histology, physiology and the culture of fungi. However, Fletcher was a fluent and popular lecturer, and wherevre he went (and he travelled widely in Canada) he left an indelible impression on the people, so that they became interested in

insects and plants. Moreover, his Annual Reports and Bulletins were widely read.

Plant Pathology is the newest of the sciences arising out of Botany. Its special field is not yet quite clear to many persons—even to many botanists. Mycology is not Plant Pathology, for the former deals with fungi, the latter with the diseases caused by fungi. The study of fungi as causative agents of disease should be carefully distinguished from the study of the diseases caused by the physiological reactions and responses of the plants to the parasites. Such pathological conditions form the field of study of the plant pathologist. To know the cause and its effect is not enough: We should know how the cause produces the effect. Then only will the treatment of plant diseases become rational and not empirical.

The plant pathologist is concerned chiefly with the diseases of plants, consequently he classifies diseases according to the relations existing between the parasite and the host. Roughly, then, he distinguishes three main types of diseases:

1. Those diseases where the parasite destroys the host and lives upon the dead or dying protoplasts, such as pear blight, many leaf spots and rots;

2. Those diseases where the parasites do not destroy the host, but continue to live symbiotically with the living cells, such as black knot, peach leaf curl, crown galls, etc.;

3. Those diseases produced by the invasion of the xylem vessels by the mycelium of the parasite, thereby cutting off the supply of nutrient solution, such as the "wilts", and many timber bracket-fungi.

It is evident that plant pathology as a science had to wait for the development of normal plant physiology and of a technique such as the bacteriologist has at his command. Moreover, a knowledge of biochemistry, systematic and morphological botany, histology and cytology is a fundamental acquirement of the plant pathologist.

Three outstanding factors contributed to the great development of our knowledge of plant diseases and methods of control:

1. The epochal investigations of European botanists on the causal organism and their relation to such plant diseases as smut (1853), the potato-rot disease (1861), and wheat rust (1865).

2. The work of American investigators in the seventies and eighties, such as Burrill, Farlow, Arthur ,Bessey, Halstead, Earle and others whose contributions added substantially to our knowledge of fungi and of fungous and bacterial diseases.

3. The work of the U. S. Department of Agriculture and of the newly established Agricultural Colleges and Experiment stations, which gave a tremendous impetus to the study of plant diseases and control measures from 1885 onward to the present.

Economic Entomology occupied a place in the public mind before Plant Pathology, because insects were studied long before fungi and the losses by insects were more obvious. They were readily recognized as causal agents of injury to plants, and were always interesting subjects for study.

While much investigation had been devoted to the structure and habits of insects, but little progress had been made in the control of injurious forms until the sixties and seventies of last century. In those decades the United States suffered serious losses from the Rocky Mountain Locust, the Potato Beetle, the Cotton Worm, and the Federal Government appointed specialists to investigate conditions. As an outcome of the reports of Riley, Thomas and Packard, strong efforts were made to devise methods of controlling these and other minor pests.

The establishment of State Agricultural Colleges and Experiment Stations about the same time gave a further stimulus to Economic Entomology, and as a result the United States have maintained the lead in this branch of science for the last fifty years.

Canada has always been in close touch with the work done in the United States, for many of the economic problems are identical. However, with her limited appropriations for the study of such problems, she has been plodding lalong in her own way, but at the same time profiting by the experience of the workers in the United States.

The economic entomologist of to-day studies the insect as the plant pathotogist does the fungus and the disease. He tries to determine all the interactions and responses between the insect and its environing factors, such as food, temperature, moisture, etc. Moreover, he studies the habits of the insect critically in all stages of its life-history—all with the object of discovering the best method of control. As both the entomologist and the plant pathologist must seek their main facts in the field where the injuries are being done, it was found necessary to establish field stations or laboratories where the investigators carry on their work. Such a departure is new, but already the results show the wisdom of it.

It is obvious, then, that the more fully the entomologist can scrutinize and analyze the various ecological factors that play upon insects, the more likely will he be able to secure important results. He should, therefore, have a fair working knowledge of botany, pathology, chemistry, geology, meteorology, physiology and agriculture, but he should confer frequently with experts in these subjects, for such conferences may often correct wrong conclusions

from his observations and even open up new and unsuspected lines of investigation.

Most of our pioneer entomologists were systematists, and as such collected a large amount of data regarding the distribution and habits of insects that have been helpful to later workers. Some of our early workers, such as Dr. W. Saunders, Dr. Brodie, and others, did much breeding work, and to them we are indebted for many valuable life-histories. To Dr. James Fletcher Canadian entomology owes a great debt for his long service of more than twenty years as Dominion Entomologist. So strong was the influence of his personality that no matter where one goes one comes across the footsteps of this great master. He laid the foundations of our Economic Entomology so firmly that the late Dr. Gordon Hewitt, his successor, was able to build a fine superstructure of which we are justly proud.

This Province of Quebec will long revere and hold in memory the name of Abbe Provancher who worked for many years almost single-handed on the insects of this province. The men of to-day are just beginning to realize the full value of the services rendered by men like Provancher, Fletcher and Saunders, of the last generation.

I cannot allow this occasion to pass without making mention of our own Society for the Protection of Plants.

This Society was founded in 1908 and has published fourteen reports. It is supported by an annual grant from the Quebec Department of Agriculture who also bears the costs of publishing the annual report. Its membership is made up of French-speaking and English-speaking persons who are interested in the protection of plants from insects and fungous diseases. At its annual meetings the Federal Entomological Branch and the Division of Botany of the Central Exporimental Farm have invariably assisted by sending some of their members to give addresses. For such services the Society is extremely grateful.

Perhaps I do not over-emphasize the importance of this small Society when I say that through its reports it, more than any other provincial agency, has brought this Province to the attention of outside entomologists and plant pathologists.

PAST AND FUTURE OF PLANT PATHOLOGY.

Melville T. Cook.

This subject can not be discussed properly without giving a considerable part of the time to the parent subject botany. In fact plant pathology is a part of botany and cannot exist without the nurture and care of the parent science. Neither is it possible to discuss the subject without giving some attention to

agriculture, much of which in its broadest sense is applied botany and which is becoming more and more dependent on plant pathology. Furthermore, it is an international subject and therefore, we will consider North America for the time being as the unit. Certainly the greater part of North America is a unit from the standpoint of race, language, and problems of public welfare.

Botany, the parent of plant pathology, is a very old science, possibly the very oldest of the sciences, although this statement will depend somewhat on our definition of a science and our ideas as to what may be looked upon as a beginning. Certainly it must have been the first science if the early efforts of the human race to protect and later to cultivate plants in order to maintain its existence or to contribute to its welfare and happiness may be called the beginning of a science. The very early written records of the human race contain reference to plants and to agriculture, but possibly the first great period in the development of botany began in Greece. Certainly it was the first great movement connected with our civilization. The early Greek and Roman scholars and philosophers studied plants with reference to both medicine and agriculture. Although confused with myths and superstitions of the age, many important ideas and facts were brought to light, such as Pliny's discovery of the value of legumes as soil improvers. In this connection, it should be remembered that the early Chinese literature also contains reference to the value of legumes for this purpose, but had no bearing on our own civilization.

Following this period of activity, there was little progress in botany until the last part of the 15th and early part of the 16th centuries, when there was a general revival throughout all western Europe. Lack of time prohibits a review of the Italian, French, German and English schools of this period; suffice to say that the prevailing idea was almost entirely utilitarian,—the study of plants as remedies for the ailments of the human flesh. Of course, a large percentage of these early students of botany were trained in the art of healing and from that time until comparatively recently, the men of the medical profession have been the patrons of botany. In fact the early history of botany in both the old and new worlds is interwoven with the early history of medicine.

The first efforts of this second period of activity in the study of plants were directed towards the identification of plants from the descriptions given by the Greek philosophers of the first period, but it was finally learned that the ancient workers were not familiar with and had not described all European plants; and also that many plants were not valuable in the practice of medicine. Therefore, the efforts of this second period were very soon directed towards describing and classifying plants. Out of this work came taxonomy, the alpha and omega of

botany. It is the very foundation of the science, but with the gradual perfection of the microscope, there arose another branch—morphology, which attracted the attention of many workers and reacted most favorably on taxonomic botany. It gave the key to the answer of many questions on structure, relationship, sexuality and spontaneous generation. Morphology was very quickly followed by plant physiology, a branch which involved amore intensive study of chemistry and other related sciences. Although the attention of these early students was directed primarily to flowering plants, they were not slow to recognize fungi and other non-flowering plants. However, their knowledge of fungi was meager and confused with superstitious ideas for many years. Fungi were supposed by many as late as the 18th century to be due to spontaneous generation. Nicander 185 B. C. said that they were "evil ferments of the earth". The Greek and Roman philosophers believed that fungi were produced by lightning and that corals were fungi turned to stone. The ideas of the 16th century were expressed by Bock (1552) who wrote—"Mushrooms are neither herbs nor roots, neither flowers nor seeds, but merely the superfluous moisture of the earth and trees, of rotten wood and other rotten things. From such moisture grow all tubera and fungi. This is plain from the fact that all the above mentioned mushrooms, those especially which are used for eating, grow most when it will thunder or rain, as Aquinias Porta says. For these reasons the ancients paid peculiar regard to them, and were of the opinion that tubera, since they come from no seed, have some connection with the sky; Porphyrius speaks also in this manner and says that fungi and tubera are called the children of the gods, because they are born without seeds and not as other kinds."

In the latter part of the 16th century (1591) Porta (a Neapolitan) came to the conclusion that all plants came from seeds, but the idea of spontaneous generation was so firmly fixed in the minds of the other workers that this view was not generally accepted until nearly 200 years later. It is unnecessary to say that the studies on the fungi up to this time were devoted almost entirely to the fleshy forms. The rapid development of the microscope during the 17th century enabled Robert Hooke, Malphigi, Leeuwenhook, Tournefort and others to extend their studies to the molds and other small forms, but did not overcome the ideas of spontaneous generation. The first great epoch in the study of fungi dates from Micheli, who in 1729 published the results on collecting and sowing the spores of many fungi. He obtained results which were remarkable when we take into consideration the crude methods he must have used. The studies of Micheli stimulated a new field of research which was given a new impulse by Persoon, De Candolle, Schweinitz, Fries and their contemporaries of the early part of the 19th century. They laid the foundations of modern taxonomic mycology without regard to existing or future economic relations.

Another great advance was marked by what may be called De Bary's rediscovery or demonstration of heteroecism among the rusts which he gave to the world in 1865. I say rediscovery because the relationship between the barberry and wheat rust had been suspected by farmers throughout Western Europe and had been demonstrated by Schoeler, a Danish schoolmaster, and published in 1818. Unfortunately Schoeler's paper did not attract attention and therefore the credit for this work is usually given to De Bary. In this connection it may be well to call attention to the fact that the Massachusetts colony passed a law in 1755 entitled "An Act to Prevent Damage to English Grain Arising From Barberry Bushes." The two forms of the rust fungus on the barberry and wheat were so unlike that the botanists were slow in accepting the ideas of Schoeler and De Bary. This was especially true in Great Britain, excepting for the studies of Marshall Ward and his students and Plowright, a physician of King's Lynn. In America, this line of work was taken up by Dr. Farlow of Harvard in 1880. However, by far the greatest progress in the study of mycology has been made within the past 75 years. The study of fungi, like the study of the flowering plants, had its beginnings in taxonomy—the chief corner stone on which we are now building the science of plant pathology. Furthermore, the development of mycology was dependent very largely on the development of the microscope during the preceding two centuries.

Although the rise of botany was due primarily to the medical profession the study of economic relationships during the latter part of the 19th century was decidedly in the back ground. Agriculture, much of which is in reality applied botany, was allowed to develop almost entirely independently of the mother subject. But it was during this period that our agricultural colleges and experiment stations came into existence and very rapidly developed into important factors in our educational, industrial and political affairs. In the establishment of these institutions, chemistry was preeminent; it was thought that the study of the chemistry of soils and fertilizers would solve all the problems of plant growth and crop production, and there are any who are still inclined to this view. It must be admitted that chemistry is the most advanced of the sciences and has done more towards increasing crop production than botany; and that the botanists have been all too willing to allow this condition to develop. However, botany was an active, although rather poor second in these institutions. In the beginning, it was usually combined with horticulture, a true branch of botany which very quickly developed into an independent subject, overshadowing the mother subject in many institutions in both activity and usefulness. This was followed by the development and separation of forestry, plant breeding and other divisions of botany. In some cases the

separation has been so complete that many people fail to see the connection or the necessity of a training in botany as a preparation for the more specialized lines of work. It appears to the writer that this is a great misfortune which must be corrected in the near future.

But let us return to the taxonomic study of the fungi, which from its beginning has been recognized as a division of bota ny and which has never been separated from the mother subject. The non-flowering plants were very mysterious to the early students of botany, and no very great advance was made with them, especially with fungi, until the microscope reached a degree of perfection which enabled the students of the subject to study the structure of the larger forms and to recognize the minute forms. Very naturally taxonomy was the first branch of the subject to be developed and this was followed later by morphology and physiology. The perfection of the microscope made possible the study of bacteria and the development of bacteriology, which may be considered a branch of botany. But it is a branch which very soon became more closely associated with animal pathology, abnormal physiology and bio-chemistry than with the mother subject. The development of these two branch subjects —mycology and bacteriology—became the foundation on which we are now building the superstructure—plant pathology. The sudden rise of plant pathology is due primarily to the extensive and intensive studies of the mycologists. In fact the plant pathology of to-day would be impossible if the were not for this mass of information, which has been accumulated by the mycologists of the past three-quarters of a century. These mycologists were well trained in botany and in most cases gave very little thought to the economics of the subject. They were what some people pleased to call "students of pure botany" but they laid the foundations for one of the most important divisions of applied botany.

Although plant pathology is of recent origin, it is just as difficult to say when it began as it is to designate the beginnings of botany. Plant diseases are referred to in the Bible, and in writings of the early Greeks, Romans and other peoples, but they were usually attributed to soil, climate, movements of celestial bodies or to some superstitions or supernatural agency. Strange as it may be, these same ideas are common within out own communities to-day The early study of the fungi did not contribute much to the study of plant diseases. However, several publications bearing directly on plant diseases came out during the latter part of the 18th and early part of the 19th centuries. The most important are *De Morbis Plantarum* by von Zellinger of the Austrian Tyrol in 1773; a second part of J. J. Plenck's *Physiologie et Pathologia Plantarum* in 1794; a work on diseases of fruit trees by J. M. Ritter von Ehrenfels

in 1795; *Pflanzen-Pathologie und Therapie* by Freiherr von Werneck in 1807; and a very comprehensive work by Count Re of Italy in the same year. Unfortunately they had no clear understanding of parasitism and therefore their work was of little importance. In fact the understanding of parasitism came rather slowly. During the early part of the 19th century it was first believed that the existence of parasitic fungi was conditioned by the host, that they were not reproduced by spores, but developed from fermenting sap of the host or from abnormal tissues. Finally when it became evident that they came from spores, it was believed that they were the products of disease, that their forms depended on the species of the host; or condition of host at time of infection. Efforts to control wheat rust by the enactment of laws were made in France as early as 1660 and in America in 1755. It is interesting to note that these same methods are being tried at this time. Treatments of various kinds have been used 150 years or more but with little success until the worker recognized the true causes of diseases. Two outstanding events did much to stimulate modern plant pathology. The first was the series of outbreaks of the late blight of the potato in Europe and America, especially the outbreak in Ireland which resulted in the famine of 1845. This demonstrated the importance of plants diseases as economic factors. The second was the discovery of Bordeaux Mixture in France in 1882 which demonstrated the possibilities of controlling plant diseases.

Having recognized and gained some knowledge of the causes of plant diseases; having learned something about the enormous losses in both wealth and human life due to them; having learned that it is possible to prevent and control them; the rise of plant pathology into a place of prominence and importance was inevitable. This rapid rise of plant pathology has made the botanical sciences more complex and more dependent on other sciences. The increasing population and the corresponding increase in the demand for agricultural products has forced the recognition of the importance of plant pathology in relation to crop production and to human welfare in general and has materially increased our responsibility to the public. It is estimated that the population of the Unites States will double within the next 100 years and that we will then have reached the limit that can be maintained by our own farm products. I suspect the same is true for Canada. Will the improvement in methods of controlling plant diseases reduce the losses, increase crop production and thus make it possible for North America to support a larger population than now estimated?

The very rapid development of plant pathology within the past few years has not been without its faults and dangers. Although the founders of plant pathology were well trained in botany, the same cannot be said of all the mem-

bers of the profession at this time. In fact we are already hearing complaints to the effect that many of the younger workers are very poorly trained in the fundamentals of botany. This criticism may be and no doubt is justifiable in many cases, but we must remember that the mother subject no longer consists of the single line of taxonomy, but of many lines such as morphology, physiology bio-chemistry and plant breeding. all of which are more or less important in the basic training of the modern plant pathologist. Furthermore the proper study of these lines makes it necessary that he study physics and chemistry. Possibly the practice of plant pathology makes it desirable that our workers should also be trained in horticulture, agronomy and related subjects. If so, the period of study becomes abnormally long as compared with the strand of human life.

What then must be the training of the plant pathologist of the future? Possibly before going farther we should define plant pathology. Perhaps the definition which would most clearly express the idea of most people who are familiar with the subject would be to say that it is the study of the causes, symptoms and control of plant diseases. You will note that plant pathology is used in a much broader sense than animal pathology. Plant Pathology is like medicine in that it has to do with the study of the causes, symptoms and results of control of diseases, but it is different in that it is concerned primarily with prevention rather than with the cure of diseases. At the present time, the demands of a rapidly increasing population for food, clothing and other plant products, and the development of an intensive agriculture to satisfy these demands, are emphasizing the importance of the prevention and control of plant diseases rather than the necessity for studying them. The result is that we are drawing on the great storehouse of information accumulated by the workers of the past much more rapidly than we are adding to it by our own researches. This is being encouraged by short-sighted legislators who appropriate public funds much more readily and more freely to the practice than to the study of plant pathology. The result is that in some cases extension men and others who have little or no training in the fundamentals of the subject are called on to practise plant pathology. In this connection we frequently hear the superficially trained workers making comparisons between the so-called practical and scientific, as though anything could be practical that is not scientific. There is no such thing as practical or successful agriculture or any other industry that is not scientific, although the operator may not be educated and may not appreciate that his methods are scientific. On the other hand the plant pathologists are frequently criticized because much of their work is hasty and superficial. This is due to the very great demand that is made on our workers for the control of plant diseases and is likely to continue unless something can be done to demon-

strate the necessity for more intensive and fundamental research. Investigations in plant pathology and contributing sciences must be encouraged if our North American botanists are to lead the world in plant pathology.

Those who view the profession from the outside may be impressed with the progress of this comparatively new branch of science, but those of us who are in the profession and see it from the inside get an entirely different view. We see before us the unexplored fields and the great possibilities. We see the great losses due to inknown or only partly know causes. We see many complicated problems which cannot be solved by any other than the untiring, well trained enthusiastic worker. We see the extremely difficult problems in fruit, field and truck crop diseases; we see the many untouched problems in diseases of ornamental plants, in the diseases of forest trees; the so-called physiological and environmental diseases; the diseases due to smoke and gas; the diseases following injuries due to insects and other organisms; the problems involving transmission of diseases; the problems involved in the study of soil organisms. Therefore, my appeal at this time is for the support of the research side of our profession; for a research that will lay a foundation on which we will build a more scientific and more useful plant pathology. My appeal is for the recognition of the superiority of scientific methods over empirical rules. My appeal is for the appreciation and support of the research man, who working faithfully in his laboratory or on a small plot of ground, seldom receives either the applause or the remuneration which are given to the practicioner of plant pathology or to the superficially trained field worker who imagines he is a plant pathologist but whose efforts would be impossible without the research with which he is so unfamiliar.

The demand for and the character of the work in plant pathology must convince all thinking persons that all plant pathologists cannot devote the major part of their time to research. We are rapidly coming to the same position as the medical profession, in which we will have our research workers, our experts or specialists and our practicioners; although the lines may not be rigidly drawn. The research workers will give the greater part of their attention to original investigation with possibly some time to teaching, they must have the very greatest freedom and must not be harassed by the demands for immediate results and applications. They must be allowed to work on fundamental problems involving taxonomy, physiology, culture methods, bio-chemistry, and other phases of the subject in which the relationship to control may be remote. The expert or specialist may devote the major part of his time to the study of a group of causal organisms, to a particular type of disease or to the diseases of some particular crop. He must be primarily a research worker and may or

may not give special emphasis to the applications and economics of the subject. The practicioner will be the man of the field, the worker who has to do primarily with the applications of the subject and who will also be an immediate advisor to the agricultural public. There will be no definite or fixed lines between these groups of workers, but they will naturally classify themselves to a greater or less degree. Each will give to and receive from the others, and the result will be the general advancement of the science of plant pathology and of agriculture.

The training of these workers will vary in degree rather than in kind. The research men must of necessity be thoroughly grounded in the mother science—botany, and in the various phases of other sciences, such as chemistry, physiology and zoology, which contribute to their proficiency. The specialists or experts must have the same groundwork with such other training as will make for success in their chosen fields. The practicioners may not be so thoroughly trained in the related sciences referred to, but they must have the groundwork and such training in horticulture, agronomy and allied subjects as will contribute to the success of control measures and crop production.

A knowledge of the taxonomy of both the host plant and the parasite must be the very backbone of the profession. We must know, we must understand so far as possible both the diseased plant and the cause of its troubles. Taxonomy may be prosaic and uninteresting to many, but it is necessary for the advancement of the science. Many of our present records are of little or no value because of incorrect determinations and many of the conflicting statements are due to the same cause. The solving of the taxonomic relationships of many groups, especially the ascomycetes and the imperfecti is extremely difficult, but it is necessary in order to solve many of our economic problems in plant pathology. This work will be materially aided by the introduction of modern culture methods.

A knowledge of the morphology and anatomy of both host and parasite is of as great importance to the plant pathologist as a knowledge of human anatomy to the surgeon. The work of Quanjer and Artschwager on the structure of the potato plant when infected with leaf-roll are good illustrations of this point. The plant pathologist of the future must know the morphology and anatomy of the host plant in both health and disease and this will lead to a development of that much neglected branch,—patho-anatomy. Furthermore, he must be familiar with the life history of both the host and the parasite in order that the treatment may be applied at the most critical period in the history of the latter, and that it may not be injurious to the former.

Many of our most serious diseases are due to fungi which live on more than one host plant, some of them having different stages which are very unlike. The wheat rust living on both the wheat and barberry, the white pine blister rust living on both the white pine and the currants and the apple rust living on both the apple and the cedar are well known examples of such fungi and there are no doubt many others that are unknown to us.

While it is true that in some cases we have been able to give successful treatments for certain diseases without knowing the life history of the parasite, it is also true that we have failed in many cases until this information was obtained. It is also true that many of our treatments have been improved as a result of increased knowledge of the history of the parasite. In reviewing the efforts at preventive measures for a period of more than 100 years we find that sulphur was frequently used with varying and uncertain results, partly because the workers of that time did not know how to prepare and apply it and partly because they did not understand the causal organisms. In fact in many cases they were ignorant of the presence of a parasitic organism. When practically all cereal smuts were known as *Ustilago carbo*, the results of the treatments were very uncertain, but when the species were separated and their life histories known, successful treatments were developed very rapidly.

Plant physiology is essential to the training of the plant pathologist because a diseased plant is one in which the physiological reactions are disturbed, regardless of cause; and because the plant pathologist is endeavoring to grow normal plants, i. e. plants in which the physiological disturbances are reduced to the minimum. A knowledge of plant nutrition was necessary for the development of plant pathology and an increased knowledge of this subject, of soil toxins, of enzymes, and of filterable and non-filterable viruses will prove the stepping stones of much of our future progress. Much of our culture work, our studies on physiological species, resistance to diseases, change in soil, moisture, temperature, and water levels will depend on our knowledge of plant physiology and ecology. De Bary was the first to clarify our idea concerning the relationship of parasite and host and although this has been the subject of considerable study, our knowledge of the exact physiological relationship between these two groups of organisms is extremely limited. In some cases the parasite is general, spreading throughout the entire plant. while in others it is restricted to certain organs or parts or organs. In some cases there is a clogging of water passages resulting in wilting, in others the excretion of poisonous substances, in others the absorption of water and food, and in others the dissolving of part or all of the cell wall.

Symptomatology is another phase of plant pathology which is very imperfectly understood. In some cases we have the destruction of parts or all of a plant, in others a dwarfing, in others an excessive growth, in others a wilting. This may appear a simple problem but diseases, like the plants which are attacked by them, are extremely variable. In fact so variable that a disease which is very destructive in one part of the world may be so insignificant in another part that its very existence may be denied.

Bacteriology, that branch of botany which was not only alienated from the mother science, but which became so closely affiliated with animal pathology and other sciences is becoming more and more of a necessity for a well rounded training in plant pathology. The honor of demonstrating bacteria to be one of the causes of plant disease belongs to the New World. Dr. T. J. Burrill of the University of Illinois in 1879 demonstrated that the pear blight was caused by bacteria. Since then it has been demonstrated that many important plant diseases are due to bacteria and I believe that I am safe in saying that North America leads the world in this line of study. However, the probabilities are that we have records of a very few of a very large number of diseases due to these organisms. Our knowledge of soil organisms, good and bad, in relation to disease and crop production is very meager and presents a most fruitful field for investigation.

The methods by which diseases are distributed are not nearly so well known as one would at first suppose. In a very general way we know that they are carried on seeds, on nursery stock of various kinds, in packing materials, in soils and manures, by wind and water, by birds, worms, snails and other animals. But the knowledge that certain mosaics are carried by insects and that cucurbit wilt is carried by hybernating beetles has aroused us to a realization of our own ingorance. In this connection, a study of zoology, especially entomology, becomes an important factor. Insects, nematodes, and other animal organisms are both carriers and causes of many diseases and this line of work must receive more attention from the pathologists.

No one who is familiar with the broad field of plant pathology in its relations not only to the mother science—botany, but also in its relation to crop production, transportation of perishables and international problems, will question the necessity for the most comprehensive training in the various divisions of botany and the related sciences, if the profession is to fulfil its obligations to the public. Although the progress in plant pathology may appear remarkable to the observer, the workers in the science know that the field is broadening and developing new relations unthought of by the founders of the

subject. Possibly no phase of the subject has received as much attention, after taxonomy, as the problems involving the life history of fungi, and yet we do not know the life histories of many of our most common species. A lack of this knowledge will no doubt explain our failure to control some of our most common diseases. Closely associated with these problems of life history are those involving the socalled "physiological species" or "strains", which are the continual sources of so much confusion. The study of these problems will necessitate improved technique in the handling of cultures and the making of inoculations, a knowledge of the factors controlling infections, the resistance to disease and the growing of resistant strains or varieties. These problems are united with bio-chemistry in one direction and with plant breeding in another. This line of work appeals not only to those who have that inborn love for the study of science but to those who are especially interested in the increase of plant production.

The diseases commonly referred to as yellows and mosaics have presented puzzling problems for more that 100 years and our progress has been very slow. We know very little about their causes, transmission or control. The recent demonstrations that some of them are carried in the weeds of the field without showing external evidence of their presence is encouraging. The solution of these problems necessitates technical training and skill of the very highest degree. The study of environmental factors, such as character of soil, temperature, other plants and insects, presents many problems which are almost untouched, but which will lead us into many fields of related sciences, such as biochemistry, soil-chemistry, ecology of plant life and entomology. This very naturally leads to geographical distribution and involves the workers to a greater or less extent in international problems.

The discovery of Bordeaux mixture in France in 1882 marks the first great step in the control of plant diseases, but by far the greatest progress in contol measures since that time has been made in the New World. We are now using many sprays and dusts for orchard, field and garden; we are treating seeds and soils; using many other methods which are familiar to this audience. But with all our progress, our treatments of plant diseases are far from perfect and present many problems for both the research and field workers Too much of our so called experimental work is nothing more or less than "cut and try" work without a scientific basis. Future research in treatment of diseases will involve a more thorough knowledge of the life histories of the causal organisms, of the host plant, and of chemistry; but will also bring the worker into close contact with the horticulturalist, the agronomist, the entomologist and the producer.

This leads directly to problems of storage and transportation which are receiving so much attention at this time.

Patho-anatomy is a field that is almost untouched. The proper study of its problems necessitates a knowledge of the anatomy of both host and parasite. While its economic bearings are indirect, it will no doubt react favorably on studies of the life histories of many organisms and indirectly on our methods of control.

Possibly one of the most far reaching phases of the subject is that of quarantine which immediately introduces interstate and international questions. Neither host plants nor diseases are respectors of international boundaries, of flags, or rulers or armies. They travel where ever the conditions permit and are frequently aided and abetted by the immediate commercial interests of the various countries. That our laws are imperfect, inefficient and frequently unjust cannot be denied by those who are familiar with the subject. The writer hesitates even to suggest a solution for these complicated questions, but certainly broader knowledge which can be gained only by international study and cooperation will prove helpful. Our quarantine laws are based on our knowledge of botany in general and our very imperfect knowledge of international plant pathology in particular. Our knowledge is not only imperfect, but provincial We must not only know more about the distribution of plant diseases, but we must know more about their symptoms and behavior under different conditions and also about the periods of incubation of many of them. A few years ago the United States Department of Agriculture was greatly exercised over the threatened invasion by the powdery scab of the potato and established quarantines which were vigourously opposed by Canada and several European countries. It is possible that a more thorough knowledge of the disease in question would have prevented much, possibly all of this annoyance to international trade. The international laws should be more uniform and there should be more international co-operation. Every nation in which agriculture is an important factor should have investigators in foreign countries and every nation should employ foreign experts to assist with various problems.

This leads us to make inquiry as to the efficiency of our present methods of education. The teaching of botany has changed very decidedly within the last half century. Fifty years ago there were very few departments of botany in the colleges and universities of North America; and in others botany was the tail piece in the departments of zoology which were masquerading under the name of biology. In fact this is true in some benighted institutions at the present time, The American botany of fifty years ago was little more than taxo-

nomy, the lines of development have been the same as in Europe; in the 80's morphology was making headway and in the 90's plant physiology was becoming a factor. During this early period, economic botany was being developed in the agricultural colleges and experiment stations by men who were trained in the universities. Even at the present time comparatively few of our workers in economic botany have received their elementary training in the agricultural colleges and the probabilities are that this will be the case for many years to come. Therefore, the obligations upon our universities is doubly great. They must train most of our botanists for all lines of botanical work. Unfortunately at the present time, applied botany is not fully appreciated by the agricultural industry, by the agricultural colleges or by the departments of botany in our large universities. Unfortunately many of our university professors are inclined to look upon plant pathology and other lines of applied botany as inferior, rather than as the climax or super-products of their own handiwork. They have forgotten that botany grew out of the medical profession and that Gleditsch, Martias, Caspary, DeBary, Sachs, Brefeld, Ward and many others who may be looked upon as master workman in the building of the science were interested in the applications of botany. They appear to have forgotten that the founders of economic botany in America were trained in our universities by Farlow, Atkinson and others whose names are deeply engraved in this history of American botany. In 1914, Dr. H. C. Cowles in his address as retiring Chairman of Section G of the American Association for the Advancement of Science said: "It would be a world tragedy if theoretical botany should die, or even if it were to be less influential than at the present time." In a recent address on "Trends of Modern Biology", Dr. Raymond Pearl called attention to "the fact that all of the activities of all living things, including man, are properly a part of biology in a greater or less degree; that the biologist may and probably does have something important to contribute towards the solution of the most various sorts of human problems, agricultural, medical, social, economic and so on." The development of applied botany if properly directed will do more than any other agency for the maintenance of theoretical or pure botany, but this will not be accomplished if our university departments of botany continue in their present attitude towards economic botany. It will be most unfortunate if the time ever comes when the research workers in plant pathology receive all their training in the agricultural institutions without being brought into closest contact with the university professors and the more strictly theoretical problems of botany. There are many problems in plant pathology that can be handled to much better advantage in our botanical gardens and large universities which are not connected with the agricultural institutions.

The reformation must begin in our undergraduate courses and extend into the graduate schools. At the present time, botany in the agricultural

colleges is too often overshadowed by horticulture and agronomy, and promising students go into these lines of work; while in many of our colleges which are not agricultural, the students are drilled in technical features of the subject which have little or no interest or meaning to them. Here, then is the greatest opportunity for the university department of botany.. All beginning students should be given, not only the subject matter of the course, but the broadest possible view of the subject as a whole in all its relations to other sciences, to human welfare and to the wealth and progress of the nations of the world. Fortunately the American Phytopathological Society has not broken away from the mother science. We hold our meetings at the same time and in some cases hold joint meetings with section G of the American Association for the Advancement of Science and with the Botanical Society of America. We co-operate with the mother subject to the fullest extent. We are also in close contact with the agricultural industries. Therefore the conditions are most favorable for the future development in the New World of the highest possible type of botany in general and of plant pathology in particular.

SOME NOTES ON SPRAY MATTERS.

By L. Caesar, Provincial Entomologist, Guelph, Ont.

Spraying Currants to Prevent Defoliation.

In Quebec as in Ontario it is probably a common occurrence for currant bushes, especially black currants, to lose all or nearly all their foliage prematurely, the defoliation sometimes occurring in July even before the fruit is picked and sometimes in August.

The chief cause of this leaf drop, so far as my experience goes, is the leaf spot or anthracnose disease (*Pseudopeziza ribis*, though the other common leaf spot (*Mycosphærella grossulariæ*) may also be a factor.

The condition favouring leaf spot is wet weather. If much wet weather occurs in May or June there is almost sure to be a heavy defoliation often as early as the end of July, especially the weather that month is hot and dry.

Having observed this defoliation of black currants for several years and believing that serious loss to the vigor and yield of the plants must result there-

from, I seized the first opportunity which presented itself of testing whether spraying would prevent the leaves from falling. This oportunity came in 1919.

That year at Burlington a field of black currants was divided into six plots. One plot was treated with Bordeaux, another with lime-sulphur, another with soluble-sulphur, another with copper-lime dust, another with sulphur-arsenate-of-lead dust, and the remaining one left untreated as a check. Three applications were given to each of the five plots and half of the Bordeaux plot received and additional fourth spray.—The first application was when the leaves were about three-quarters of an inch wide; the second soon after the blossoms began to appear; and the third when nearly all the bloom was over. The fourth spray on half of the Bordeaux rows was given two weeks after the third.

The results were interesting not only to myself but to all others who saw them! The check rows and all the rows except those on which Bordeaux or lime-sulphur had been used had lost practically all their foliage by the end of the third week in July; at which date the fruit had not yet been picked. The lime-sulphur row was badly affected with leafspot but most of the leaves remained on until August. The Bordeaux rows retained their foliage not only throughout July and August but up to the end of the season. The half of this plot which had received four applications had better foliage than that which had received only three applications but the difference was scarcely great enough to justify the extra spray.

The next spring the plots were again examined just as the buds were bursting. The benefit from Bordeaux once more showed up in a conspicuous way for the buds on this part were all green and bursting, whereas on the other plots fully half were dead. This was due to the fact that the Bordeaux rows by retaining their foliage had been able to supply the necessary food throughout the growing season to put the buds into proper condition for winter and for the next spring, whereas the check and other rows in consequence of losing their foliage early had not been able to do this and so the buds had been starved and died.

As one would expect the benefit of the Bordeaux spraying showed up also at the time of harvesting, for the only rows worth picking were those on which Bordeaux had been used.

In 1920 another spray test in a different field was made but that year the season was unfavourable for the development of disease and in all cases foliage held on fairly well through the season. Bordeaux rows, however, even under these conditions had in my opinion sufficiently better foliage to justify the spraying.

I feel satisfied therefore that to get the best results from his currant plot, especially from black currants, the grower should keep the foliage well sprayed with Bordeaux throughout the months of May and June or in other words until nearly the time when the fruit is ripe. The greater vigor of the plants and the increased annual yield will much more than pay for the material and time required in spraying.

No poison need be used on black currants, because the currant worm does not attack this variety. However on red currants poison should be added to the second application to destroy the worms.

Value of a Casein-Lime Spreader.

Casein-lime spreaders, especially the brand known as Kayso, were widely advertised last year and were tested by many experimenters almost all over North America. I used Kayso along with lime-sulphur and arsenate of lead on about 75 McIntosh and Fameuse trees in Norfolk county and in doing so followed closely the directions of the manufacturers. The substance mixed well with the water and the other spray ingredients and gave evidence of being a good spreader. It was used first in the spray just before the blossoms opened and then in the one just after the blossoms fell. On examining the leaves soon after the spraying was done, one felt well satisfied that the spreader had helped to make a thorough job and had given a more uniform covering then would otherwise have been the case; but ten days after the later spray the orchard was again examined and the leaves on all four rows found to have numerous small brown specks which were clearly due to the Kayso, as the leaves on trees along side in which this substance had been omitted had no injury. So numerous were these spots on the Kayso rows that I felt that another application of this substance would be altogether too dangerous, and so it was omitted in the next spray.

The codling moth was so well controlled all over the orchard by all mixtures that no conclusions can be drawn as to the value of the spreader in the control of this pest.

Early scab, that is scab which developed before the first of July was well controlled on the rows in which the spreader was used but the difference between these rows and those alongside was only approximately 1%, this being in favour of the Kayso.

In addition to my own results I learned at Rochester in January the results from this spreader obtained in New York. The Entomologists there were agreed that the benefit from casein-lime spreaders was so small that it would not pay for the extra expense incurred in purchasing the material.

In New York they had no injury from burning but in a number of other places in the United States burning did result just as it did with me.

My conclusions therefore drawn from my experience and that of several other entomologists are, that if spraying of apples is well done, the spreader is not necessary and will not pay.

Dry Lime-Sulphur as a Substitute for Liquid Lime-Sulphur

The Canada Paint and Sherwin Williams Company are selling a dry lime-sulphur which is in the form of a fine orange-yellow powder which dissolves readily in water. When arsenate of lead or arsenate of lime is added to the mixures the colour still remains a much deeper yellow than in the case where liquid lime sulphur and these poisons are mixed together.

I tested this dry lime-sulphur this year on seventeen McIntosh trees, using it not at the strength which the company recommends but roughly at a strength worked out in conjunction with our chemist after he had made analysis of the substance. In the first application I used 6¼ pounds to 40 gallons of water and applied it soon after the buds had burst; in the second application 5 pounds were used and applied just before the blossoms opened; and in the third application 4 pounds and applied just after the blossoms fell. One pound arsenate of lime and 4 pounds hydrated lime were added to every 40 gallons in the 2nd and 3rd applications.

Though the conditions were very favorable for scab the trees sprayed with this substance were just as free from the disease up to July 1st as those sprayed with the liquid lime sulphur, the average scab on this row and the rows alongside being a little over 3%. But after July 1st there was a decidedly heavier outbreak of late scab on this row than on any other of the 32 rows in the orchard. This would tend to indicate that the spray did not adhere so well or have such a lasting effect as the liquid lime-sulphur. Yet perhaps it is scarcely fair to draw definitie conclusions from one year's expperience.. However as dry lime sulphur is a very convenient type of spray material I believe we ought to test it out further and see whether at a greater strength it will prove satisfactory. It would be especially convenient for owners of small orchards or of a few trees in a garden and would be sold by merchants in small towns who would not handle the liquid mixture.

. . . . . .

Mr. Petch—Dry lime sulphur has given me very poor results.
Mr. Caesar—What strengths did you use?
Mr. Petch—The strengths recommended by the manufacturers.
Mr. Caesar—I think that in the past these have been too weak.

The Comparative Susceptibility of McIntosh and Fameuse Apples to Late Attacks of Scab.

I have usually considered that there was not much difference in the susceptibility of McIntosh and of Fameuse apples to this disease, both being well known to be very susceptible I am still unable to say whether there is any difference in their susceptibility to early attacks of the disease, because ordinary spray mixtures if properly applied will control the scab on either variety; but this year in a ten acre orchard consisting of alternate row of McIntosh and Fameuse I discovered a distinct difference in the degree of susceptibility to late infections.

The whole orchard received the regular three sprays and in addition part of each variety received a fourth. On both McIntosh and Fameuse the scab was fairly well controlled in the early part of the season, there being an average of slightly over 7% on the McIntosh and slightly under 7% on the Fameuse. As check McIntosh trees lost every apple and had most of their early leaves destroyed by the scab the year was clearly very favourable for the disease. After the first of July a late infection began in the orchard due to wet weather the last week in June and also later in the season. Under these conditions I was surprised to find that the McIntosh proved much more susceptible to the disease, the total late scab on Fameuse being 24.2% and on McIntosh 66.6%; that is, McIntosh were nearly three times as badly affected as Fameuse under exactly the same conditions of weather, soil and situation. This is a striking difference and the conclusion one is forced to draw is that we must use more vigilance in a wet season to keep McIntosh free from disease than Fameuse.

When Shall we Apply the First Spray to Apple Trees?

A very important question is—When should we apply the first spray in apple orchards in which there is no San José Scale and not much Oyster Shell Scale or Blister Mite?—a condition which must be common in Quebec.

A study of the life-history of the fungus would indicate that there is little value in spraying for this disease before the buds burst and that we should wait at least until the bursting has taken place and green tissues are exposed to infection. But there are green tissues exposed to infection from the time the buds are bursting until the regular pinks pray is applied just before the blossoms open; moreover, as the leaflets keep increasing in size during this period and the blossom bud clusters begin to push forth towards the end of it, it is impossible for any single application, no matter when applied, to give complete protection throughout the period.

Theoretically the ideal course to follow would be to have the weathermen warn us at least two and better three or four days ahead that a spell of wet weather is coming and to have the fruit grower take advantage of this warning and spray at once. Unfortunately the weathermen can seldom predict the weather so far ahead. There is also the further difficulty that even if they could there would not infrequently be more than one such spell, thus requiring more than one spraying. Now so far as I can judge it would be difficult to convince our fruitgrowers that they should give more than one spray before the pink spray for experience seems to show that more than one would seldom pay. So that the question comesdown to, what time should the first spray as a rule be given to secure the best results.

Many answer this by saying "Spray when the leaflets are the size of a mouse's ear." This has worked fairly well but I believe that, inasmuch as our main object is to keep the fruit protected it would be wiser to direct our growers to postpone the spray just as late as possible and yet be able to finish it before the pink spray should begin. So my suggestion would be to wait until the blossom-bud clusters have appeared on the earlier varieties and are just beginning to do so on most of the later ones. By spraying them we should be taking the earliest opportunity to protect the fruit itself from scab; for the bases of these blossoms develop into the fruit itself and so an infection on them means a scabby apple. This late date of spraying would some years allow some danger of the leaflets becoming infested before the application was given, but the infection would seldom be great and it seems to me safer to risk leaf infections than fruit infection.

There has occurred to me a possible alternative in the nature of a compromise between this late date of spraying and spraying soon after the buds burst; namely, to spray the whole orchard from one side, with the wind, as soon as the buds have burst and the leaflets are just beginning to appear and in doing so to try to cover most of the tree by stopping just as you come to it and shooting the spray all through it in one definite direction and then, after driving just past the tree shooting the spray back all through it in a direction about right-angles to the first direction; then after this application to wait until the blosson-bud clusters, as said above, were appearing and spray the opposite side of the tree in the same thorough manner.

Some would call this two applications but if so they would take very little more time than an ordinary spray and would not only protect the fruit but do much to protect the foliage also.

I am throwing out these suggestions with the hope that by further experimenting we may be able to improve upon our recommendations to fruit growers.

It is scarcely necessary to state that if lime-sulphur is used for this spray it need not be stronger than about 1 gallons to 35 gallons of water and no poison would ordinarily be required.

If dust is used instead of liquid I think I should be guided largely by the weather, I should dust first whenever wet weather threatened after the buds had burst and leaflets were beginning to show and then give another application when the blossom-bud clusters were appearing.

DUSTING VERSUS SPRAYING.

By G. E. Sanders, Deloro, Ont.

The question of dusting versus spraying is one that continues to be discussed at every Horticultural Meeting just as twenty years ago no Entomological Meeting was complete without a discussion as to the relative merits of Paris green and lead arsenate. Twenty years ago, there were certain places where Paris green was superior to other poisons then on the market. So with liquid spraying today.

I have probably conducted as many small plot tests of liquid and dust spraying experiments as any man in this room and have visited almost as many fruit sections and orchards as any of you during the past three years and I want to say to you that when experimental plots, say even acre plots, begin to run within five per cent of each other in insect or fungus control, then, it is beyond the power of the experimenter to say from data obtained from his own plots which material is going to give the cleanest fruit when placed in the farmers' hands.

In a number of reports I have published the data gathered by Prof. H. H. Whetzel of Cornell which gave a summary of 4 years' dusting in New York, Nova Scotia, Illinois and Michigan, a total of 16 years' experiments, comparing the fungicidal value of sulphur dust and lime sulphur spray. By a singular coincidence, this data averaged the same to one-tenth of one per cent in apple scab control. This data was all secured by professional experimenters, some of whom had good dusting machines and some poor; some had good spraying machines and some poor ones. On the whole, I have found that experimenters spray more efficiently than the average farmer while they do not dust nearly as efficiently. They usually do their dusting on the same days as they do their spraying regardless of weather conditions, and often, owing to the indefinite relations between the experimenter and the orchard owner's hired man,

the experimenter does not dust so early in the morning as the average grower.

Last year I came upon a new type of data. One of the bankers in Williamson, N. Y., decided that he would find out how dusting really worked out. He sent a man to every grower shipping apples into Williamson and got the full data on material used, average crop and pack out of the fruit.

Pack out of all apples shipped through Williamson, N. Y., Season of 1921-22.

No. of Orchards	*Total No. acres*	*Treatment*	*Percentage "A" Grade Fruit*
32	1.011	Dusted	48.6
247	3.348	Sprayed	11.4
34	149	Untreated	1.1

This is rough data and some of the sprayed orchards gave excellent fruit and some of the dusted ones poor fruit, but there are some things here that cause us to wonder. We find here that the growers are not getting the same relative results from spraying and dusting as the professional experimenters are getting. Apparently the farmer is not doing his spraying as thoroughly as the experimenter and he is doing his dusting a little better. These differences in results make us wonder whether we would serve the country better by advocating dusting or by advocating spraying.

Some of you may say, "That is the opinion of a dust enthusiast who is now manufacturing dusting material". That is true, but let me tell you that for immediate profit there is more money to be made is Paris green, a material that we manufacture and do not recommend, than in all the dust that has ever been made. We have to manufacture what the public demand. In such a gathering as this I try to recommend what I think is best irrespective of the profit that may be in it.

The question of dusting vs. spraying is one that the farmer has been forced to settle and is settling to his own satisfaction since experimental data is not proving to him an accurate guide as to what he can accomplish in his own way in his own orchard.

I think that I am safe in saying that 95 per cent of the experiment station workers refuse to recommend dusting yet. I know of numerous questionaires that have been sent out to orchardists who are dusting and invariably over 95 per cent of the users have expressed themselves as satisfied with the method. On a recent questionaire sent out in the United States 97 per cent of the owners of dusters stated that they intended continuing dusting. There is

cause for some pretty serious thought in these differences. Are the experimenters falling down in their dusting operations? Are the experiments not being conducted in a way that makes the results applicable to orchard conditions? Or are the experiment station men doing their spraying much better than the farmer and doing their dusting no better than the farmer?

Personally, I think that the greatest cause for these differences is the fact that the average farmer will, if anything, both time his dusting better and apply his dust better than the experimental men, and when spraying he will not do anything like so thorough a piece of work

The big objection to dusting has in the past been the cost of materials. Everyone agreed that dusting saved eighty percent of the time of application, the initial cost and depreciation of the machinery was lower and the life of the machine twice as long, the weight of the machine much less, making it more desirable on both hilly and wet ground, and the results obtained satisfactory to farmers. The price of dusting material has in the past been high,—about double the cost of spraying material, and has been the one big obstacle to the spread of the method. In 1918, the introduction of Blue Copper Arsenic dust, which is made up of monohydrated copper sulphate, hydrated lime and arsenate of lime, lowered the cost of dusting materials so that, reckoning the saving in time and equipment, the total cost of dusting was brought below the cost of liquid spraying. This year, for the first time in the history of dusting two dusts are on the market that cost the grower about the same as the materials for liquid spraying. These are what we term Brown Copper Arsenic dust and Green Copper Arsenic dust.

Brown Copper Arsenic dust in the formula 4½-2, which is used on apples, contains 18 lbs. of copper sulphate crystals and 8 lbs. of arsenate of lime in the hundred, the remainder being made up of hydrated lime. Green Copper Arsenic dust, in the formula 9-5, which is used on potatoes, contains 36 lbs of copper sulphate crystals and 5 lbs. of metallic arsenic in the form of arsenites, or the equivalent of either twenty-five pound of arsenate of lead or twenty pounds or arsenate of lime in the hundred, the remainder being made up of hydrated lime. These dusts are being retailed in both Canada and the United States at approximately the same price as the farmer can buy the equivalent amounts of copper sulphate, lead arsenate and lime for making liquid Bordeaux, thus making dusting materials, for the first time, as low or lower in price than the materials for liquid spraying. This removes the greatest single objection to dusting. Both these dusts will be largely used commercially this season and their exact status as fungicides and insecticides determined.

Nicotine Dusting.

During the past six years, great changes have been made in nicotine dusting. The first nicotine dust made by Prof. Smith of California was nicotine sulphate sopped up in dried china clay. The nicotine in this material was almost completely non-volatile and, in view of our present knowledge, it is a wonder that dusting with nicotine ever got by the initial stages. Luckily it was used first on the walnut aphis, which is very easy to kill and the thick foliage of the walnut tree held what vapors were liberated until they had done their work. On almost any other insect or on any other type of tree the original nicotine dust would have been branded a failure. There is a lesson here that should prevent us from forming too hasty judgments on new materials. Later, some one found that the addition of a small quantity of lime made nicotine dust more effective. Then some one found that it was the volatile nicotine that did the killing, that nicotine dusting was gassing or fumigating and that it was not necessary to actually hit the insect with the dust in order to make a kill.

During the winter and spring of 1921-22, Dr. Headle of New Jersey began a series of experiments on the rapid volatilization of nicotine from dust. The Headle dust formulas have increased the value of nicotine dusting materials by from five to twenty times, depending on the honesty and intelligence of the various commercial concerns applying them. Let me illustrate.

On the whole, dusting has made remarkable progress during the past season, for the most part on its own merits. The highest yielding potato field on Long Island was a dusted field. Potato dusting on Long Island and in Maine was fully as satisfactory as spraying, while in Florida it surpassed spraying on account of the extra stimulation resulting from the dust. Where at the beginning of last season one dusting machine was working on citrus in Florida, by the end of last season one concern had sold 109 power dusting machines in Florida for citrus work. This year the same concern is placing over 100 power dusting machines in one county in Florida.

In Nova Scotia they bought 200 more dusting machines last season, dusted 80 per cent of the crop and grew the cleanest crop as well as one of the largest crops since 1911. Since Nova Scotia took to dusting in a large way in 1919, they have grown four large, continuous crops that have averaged more than double the average of the previous seven crops when they were spraying with lime sulphur.

At the meeting of the New York State Horticultural Society two months ago, the evidence of the growers was all in favor of dusting, the largest growers in New York State, Collymer Bros., stating that if they had dusted their entire

crop they would have had 5,000 barrels more fruit and 20 per cent more of that "A" grade.

Nicotine dusting has progressed to such a point that outside of the scale insects, dusting gives much more satisfactory control of sucking insects than spraying. Such insects as pea aphis, which could never be satisfactorily controlled by spray, are now easily controlled by dust.

Last spring the best nicotine dust was one containing a total of 6 percent of nicotine sulphate or 2.4 percent of nicotine. Of this 3.75 percent of the nicotine present was volatile, or the total dust contained 0.09 percent of volatile nicotine. This dust did fair work in the control of moderately resistant insects. By the end of the season dusts containing a total of 2.4 percent of nicotine and 0.26 percent of volatile nicotine were on the market. This last dust contained slightly less than three times as much volatile nicotine as those sold earlier in the season, but in practice one-fourth as much dust per acre gave better control of sucking insects than did the earlier dusts. Today the Headlee idea is being applied with the result that dusts are being made with from 40 to 60 percent of the total nicotine in highly volatile form. I know of one dust in particular that is being placed on the market which only contains a total of 2.0 percent nicotine but 60 percent of the nicotine, or a total of 1.2 percent of the dust, is volatile nicotine. This dust contains less total nicotine, yet it is over twelve times as valuable per pound as the best dust on the market at the beginning of last season and twenty times as valuable as others.

On ground crops you can increase the efficacy of nicotine dusting by dragging a sheet for twenty feet over the crops, tying the sheet to the boom, thus confining the fumes. This almost doubles the value of a nicotine dust.

At the end of 1922 nicotine dusts were successfully controlling such insects as pea aphis, potato aphis, pear psylla and other insects that have in the past been almost immune to the former nicotine dusts and very difficult to control by spray.

There will, in the future, be many arguments pro and con on dusting but as I see it the dusting method is going to win, perhaps slowly, but it will win in spite of anything that can be done to prevent it. The low cost and low upkeep of a dusting machine, the speed of application, the low-priced dusting materials now available and the fact that the average farmer makes a better job of dusting than he does of spraying are factors that are going to cause dusting to increase.

It is impossible for dusting to succeed with high-priced dusting materials, but it has been my experience that just as soon as the cost of dusting is made approximately the same as the cost of spraying, the growers are going to dust instead of spray. Whether they get a few more or a few less No. 1 apples

or whether they get a trace of net russetting does not count and all of the evidence that I have goes to show that the average grower or the average locality will grow more and better apples by dusting than by spraying because the average grower will dust more thoroughly than he will spray.

I want you to understand that I am not questioning here the accuracy of the data that has been submitted by official experimenters nor am I questioning the honesty or sincerity of experimenters, either individually or as a class. However, I am convinced that the average farmer will get better comparative results from dusting than will the average experimenter.

PROVANCHER THE CANADIAN LINNAEUS.

HIS LIFE AND WORKS.

By Georges Maheux, provincial entomologist, Quebec.

During the last five years, Canadian naturalists and scientists have heard more about Provancher than during the previous quarter of century, Scientific societies, reviews of all kinds and even the daily papers have in succession paid warm tributes of admiration to the high value of the late Abbé Provancher as a priest, citizen and naturalist.

One day, in August, 1918, a large group of friends, admirers and disciples gathered in the Provincial Museum at Quebec. The object of the meeting was the celebration of the 25th anniversary of the death of Provancher and the unveiling of a tablet presented by the Quebec Society for the Protection of Plants and bearing the folloing inscription.

A la mémoire de Provancher, Naturaliste et Entomologiste, 1820-1892.

A few months before, in the church of Cap-Rouge, where the remains of Provancher have been piously kept, Canon Huard erected another memorial with the financial aid of the Ontario Entomological Society and numerous other institutions. Nevertheless, all the publicity accorded to the name of Provancher fails to give anything like a complete idea of his career; the entomologist regards him as an entomologist, the botanist as a botanist, while the man was really the Linnaeus of Canada; that is to say a true naturalist in the broadest sense of the word, having been interested in and written competently on the various kingdoms of Nature. The complete list of his works reveals

a great similitude with Linne's Systema Naturea, at least, as to the subject treated and the division into classes, orders, genera and species. The resemblance is much more striking when we come to compare the means of study followed by both naturalists, though separated by more than a century of marked progress in the field of natural sciences. Like Linnaeus, Provancher might have said at the end of his life: "Ea quæ Facimun sunt pars minima eorum quæ ignoramus", but know that his life was well filled and that his work added substantially to the sum of human knowledge.

Born at Bécancourt, province of Quebec, on March 10th, 1820, Provancher received his education in the newly erected college at Nicolet. There, under the shade of lofty pines, he picked up some flowers which determined his passion for the things of Nature. There on the dusted shelves of the library he discovered, by chance, an old text-book of botany that helped him greatly in his new studies. These studies were quite private, for until about 1835, the teaching of natural sciences was still in the womb of the future.

At the end of his classical course, in 1840, Provancher decided to become a priest and he refrained for a while from his scientific ambitions. He occupied various positions in many parishes between 1844-1847. In 1847, he devoted himself to the service of some hundreds of Irish immigrants, stricken down with an epidemic of typhus. His heroism upon this occasion gives an idea of his unselfish character. Though nervous and rather irascible, he concealed under a coarse appearance the heart of a true friend, always frank and generous.

The active scientific life of Provancher began in 1848 with some essays on grafting that met at first with failure, but that brought back his attention to botany through the channels of horticulture. When transferred, in 1855, to St. Joachim at the foot of Cape Tourmente, Provancher was chiefly interested in botany and we see from his writings in various papers that he strongly advocated the teaching of natural sciences in all schools. To give a proof of his convictions along these lines and to help to realize this plan, 3 years later he published a "Traité élémentaire de Botanique" which was soon adopted by numerous educational institutions.

With this first production Provancher took rank among educators. In 1859 his " Tableau chronologique et synoptique de l'histoire du Canada" was published with the same object in view. While at St. Joachim, Provancher with his devouring activity, commenced experiments on the varietal resistance of fruit trees that can be grown successfully around Quebec. In the newspapers of those days he wrote many articles to convince the farmers of the necessity and advantage of growing fruit trees. His untiring efforts resulted in the planting of a very large area with apple and plum trees, most of which lasted over half a century, the last survivors being killed a few years ago by a severe winter.

Transferred to Portneuf, in 1860, Provancher continued his Horticultural experiments with great success even establishing a fruit tree nursery for the advantage of the farmers of this county. Two years later, he was ready to make known the results of his experience as a fruit grower. How new work published in 1862 and entitled: "Le Verger Canadien" has been until lately the classic guide of fruit culture in the Province of Quebec. This little book reached its fifth edition in 1885;; for the economic entomologist it contains a very interesting section, namely the chapter dealing with the insect pests of the orchards and describing the means of controlling them. This was, in all probability one of the first expressions of applied entomology ever presented in book form in Canada. But it is not the first in date. Provancher was known almost exclusively as a systematist; nevertheless, the first paper he published in his life was a discussion on "Insectes et maladies nuisibles au blé" an essay prepared for a competition on this subject organized by the Department of Agriculture for which Provancher received a third prize (under the nom de plume of Emilien Dupont).

The first important work of our great naturalist was published in the year 1862: it is the voluminous "Flore Canadienne", the first and only complete work dealing with Canadian plants. Heretofore, no other worker has dared undertake the gigantic task of revising and completing this now old treatise.

Every Canadian and American entomologist knows Provancher as a pioneer entomologist, and it is as such that he merits fame. His systematic classification of insects modestly entitled "Petite Faune Entomologique du Canada" fills four compact volumes making a total of 2506 pages as follows:

Vol. I.—Coléoptères and additions.
Vol. II.—Orthoptères, Nevroptères, Hymenoptères.
Vol. III.—Hémiptères.
Vol. IV.—Additions and corrections to Hymenoptères.

There may be found the description of all the Canadian species contained in his collections, many hundreds of which were unknown to science. In the order of Hyemoptera alone, Provancher described 923 new species. Rohwer and Cahan, of the Washington Bureau of Entomology have pronounced the accuracy of his descriptions and pointed out some mistakes in referring species to the wrong general.

From 1868 until his death in 1892, Provancher devoted much of his time and resources to the maintainence of his review" Le Naturaliste Canadien". The editor filled with his own pen most of the 20 volumes of this publication (nearly 8,000 pages). Apart from insect studies that were later published in book form, this collection contains an elaborate classification of vertebrates, a study on the birds of Quebec, vermes, etc. A volume on Mollusks was

published about 1888 and two years later 2 volumes of travels, one to Jerusalem, the other to the West Indies.

Besides all these occupations Provancher found time to contribute regularly to such weekly papers as "la Minerve" and "La Gazette des Campagnes". These articles discuss a great variety of subjects especially agricultural and educational. Sometimes he severely criticized public authorities, for instance when the government cut off the annual grant given by previous administrations for sustaining the "Naturaliste Canadien". The life of the publication was seriously menaced three times by such decisions; in 1880, 1883 and again, in 1890.

Provancher's activity never knew any limit and left its distinctive mark in many fields. He was known as a very successful organizer, as well in building churches, in organizing two Canadian pilgrimages to Jerusalem and as the promotor of a steamship company, etc.

In 1888, he started a new publication, "La Semaine Religieuse" a weekly review that is still in existence. During his life he had the pleasure of seeing a large group of learned men interested in natural sciences, many of them being his own disciples, whose studies he directed personnally. Such were: Canon Huard, his successor as editor of "Le Naturaliste Canadien" and now curator of the Public Museum, Quebec; Abbé Laflamme, late professor of Natural history at Laval University and a geologist of wide reputation, F. X. Bélanger, entomologist, late curator of the Zoological Museum of Laval University; Dr Crevier, microbiologist; Dr St-Cyr, geologist and many others.

When Provancher died at Cap Rouge, March 23rd, 1892, at the age of 72, he could see the realization of the dream of a life time; the natural sciences being then taught in all the colleges and many young men interested in various branches of nature study.

He has been honored by Laval University with the degree D.Sc.; he was a charter member of the Royal Society and member of man European and American scientific societies.

His three collections of insects may be found at the College of Levis and at the Quebec Public Museum. All other specimens collected by Provancher have been kept with care by Rev. Canon Huard, who for the last 30 years has kept alive the memory of the Canadian Linnaeus.

PLANT DISEASES OF 1922 IN WESTERN QUEBEC.

By B. T. Dickson.

In presenting this account of the plant diseases observed during the season of 1922 the writer feels impelled to explain that the lack of more exact data regarding prevalence and economic importance is due to the author's undesired vacation in hospital. It is felt, however, that even a somewhat fragmentary account is of value in helping to survey the Dominion as a whole. I wish to thank Mr. J. G. Coulson of this Department for obtaining much of the information herein recorded.

Potato.—Early blight (*A. solani*) was quite common and in August-September the foliage was considerably spotted. The spots were not large and rarely coalesced and it is not likely that the resulting loss in yield was appreciable.

Late blight (*P. infestans*) was not seen to any extent.

Mosaic was present, as was Leafroll, but not serious, although aphids were found in numbers during mid-October.

Hopperburn was prevalent during September and leaf-hoppers were common on late varieties.

Black dot disease.—This disease, which is being studied by the author was of frequent occurrence during the latter part of this season. In some fields it was present to the extent of 5%. It is impossible to say yet whether it causes serious injury but it was usual to find affected plants dying down two or three weeks earlier than healthy ones in the same plot. The root systems, stolons, and ground-level stem tissues are attacked and killed. The development of tubers depends upon the stage at which the stolons are affected. Many tubers with the black-dot sclerotia on the surface were found.

Tomato.—Mosaic was present but not to the same extent as during 1920 or 1921.

Leaf blight, caused by *A. solani*, was very common during late August and September and spotting of the fruit with a subsequent rot occurred in September.

Bean.—Anthracnose (*C. lindemuthianum*) and blight (*Ps. phaseoli*) were prevalent, the season being ideal for their development and rapid spread

Mosaic less noticeable although frequent.

Stem-rot and wilt caused by *S. libertiana* was of local occurrence but quite common.

Pea.—Mosaic was found in rather isolated areas but Stigmonose caused by *Macrosiphum pisi* was the cause of heavy losses in late crops.

Pod spot (*Ascochyta pisi*) was common.

Cucumber, Melon, Squash.—Wilt caused by *B. tracheiphilus* occurred in practically every plot. The wilting was of the slow-developing type.

Onions.—Onion smut (*U. cepulæ*) was serious in several large areas near Montreal.

Downy mildew (*P. schleideni*) occurred in isolated areas and while it alone was not serious greater loss was sustained because it was followed rapidly by *Botrytis sp.*

Pink-root or root-rot (*F. malli*) was present and serious and again the wilted leaved were attacked by *Botrytis sp.* and the loss aggravated.

Celery.—Leaf and petiole blight (*S. petroselini apii*) was common and serious on Paris Golden but Self-blanching was only slightly affected.

Clovers.—Powdery mildew (*E. polygoni*) was present to an astonishing extent—fields of clover (*T. pratense*) looking as though powdered with white flour.

Mosaic was again common in certain areas.

Sooty spot (*Polythrincium trifolii*) was of frequent occurrence but did not cause any perceptible loss.

Cereals.—Oat smut (*U. avenæ*) and barley smut (*U. hordei*) were present.

Stinking smut of wheat (*T. tritici*) was found in isolated cases but was not serious as was also the case with Loose smut (*U. tritici*).

Fusarium blight in heads of rye and wheat is apparently commoner than expected and a similar blight in corn was not difficulte locate as a rule.

Ergot of rye and timothy was note as rather more prevalent than usual.

Sunflower.—Samples of sunflower stem suffering from Sclerotinia rot and wilt were sent in from all parts of Quebec indicating its widespread occurrence It has been impossible to ascertain the infection percentage.

Rust (*P. helianthi*) was exceedingly common (75%) during September.

Apple.—Brown rot (*S. cinerea*) was noted from many sources on Yellow Transparent and Montreal apples.

Black rot (*Physalospora cydoniæ*), while not common, was frequently found.

There was a heavy scab infection (*V. inæqualis*) wherever spraying was not done or where orchards were poorly sprayed.

Two interesting diseases were noted:—Phyllosticta leaf-spot (probably *P. solitaria)* in one orchard to the extent of 100%. and Bitter rot (*G. rufomaculans*) in two orchards on Fameuse apples but only to a slight extent.

Plums.—Wild plums were heavily infected by *Exoascus pruni* causing "bladder plums" but cultivated varieties were not affected. On the other hand the latter suffered from brown rot (*S. cinerea*) to the extent of about 1%.

A "wither-tip" the etiology of which at present is not known was sent in from New Brunswick.

Raspberry.—Mosaic and Leaf curl were still present, the season being such that the former was especially noticeable. In this district the Columbia variety must be added to the susceptible list.

Grape.—Grape mildew (*P. viticola*) was common this year on leaves, tendrils, shoots and fruit.

Elm.—On most American elms in Eastern Quebec there was approximately 30% infection with *Dothidella ulmi* causing leaf spot.

Butternut.—*Gnomonia veneta,* causing leafspot, defoliated practically all the butternut trees at least a month earlier than normal.

Iris.—Rhizome-rot caused by *B. carotovorus* was prevalent wherever this ornamental plant was grown. There appeared to be little doubt that injury to the rhizome during spring cultivation opened infection courts in the plants.

Sweet pea.—Mosaic was noticeable in many plots but was not so common this year as "stigmonose" and leafcurl caused by aphids.

Streak (*B. lathyri*) occurred frequently, especially during September.

Peony.—Leaf and stem spot caused by *Septoria pœoniæ* var. *berolinensis* was very pronounced.

Botrytis blight was present but not serious.

During the later summer an Alternaria leafspot a Phyllosticta spot and Cladosporium blight became common.

In one large nursery the roots of newly planted peonies blackened and died. They were like india-rubber in texture. The trouble appears to be due to a species of Fusarium.

Contribution No. 15, Dept. of Botany, Macdonald College, Que.

THE SEED PLOT AS A MEASURE OF PROTECTION.

By Omer Caron, Botaniste, Quebec Dept. of Agriculture.

The technical expert can in many cases control diseases by carrying out certain technical measures, but in the field the efforts of growers to do this are often nullified by causes beyond his control.

When one considers the practical aspects of plant protection, it is found that some are difficult to follow because of the cost of labour and the amount

of time required. It is important therefore to popularize natural methods of combatting parasitic fungi. As a result of many inspections, demonstrations, and complaints from one end of Quebec to the other, I have decided to urge the use of isolated seed plots.

In selecting seed, improving present varieties and creating and conserving new types, investigators confine their attention especially to individual plants. The idea now suggested is to use this method in a modified form by growing seed at home in carefully tended plots. This should not give one the impression of an experimental farm with its chequer board of experimental plots. It merely means that each farmer should set aside a small plot of land, or two or three small plots, isolated from the crop fields. In these plots he will try to grow clean seed or tubers for his own farm. Such efforts are especially desirable in the case of loose smut of wheat and in potato diseases.

Concerning loose smut of wheat, we say to farmers "Treat your grain by the hot water method", but it is much more difficult to do than to recommend. Many intelligent men have been disappointed at the results obtained. If a farmer does not succeed the first time he usually renounces the project—a result which is deplorable. The disinfection of large quantities of wheat against loose smut is impossible because the farmer is not equipped as a chemist and physicist. I realize that my remarks will probably engender the criticism that I am retrogressive, but put yourself in the place of the farmer and you will see better my point of view.

We tell them to buy good seed. At present it is almost impossible to obtain wheat free from smut and potatoes free from Mosaic or Leafcurl. The guarantee certificates are only valuable if the producer is honest. The fact that farmers in some localities are obliged to purchase seed in large quantities, facilitates the inclusion by the dishonest seller of second and even third rate seed tubers.

If we think of the continued spraying with all the necessary equipment, and of the initial disinfection, it is not surprising that many growers are irritated and do not carry out these precautions. Often the sprayings come at times when work is multiplied, during haying, hoeing, harvesting or when it is necessary to use men and horses on municipal work to reduce taxes somewhat. Those who have only a small acreage can manage, but it is the larger producers who often cease to practise control measures. I am not excusing him, but I am explaining the reasons which in many cases account for his action. Nevertheless what is not practicable on a large scale can be done in a small way in the isolated seed plot. To spot plants with wheat smut or potato mosaic is not easy on a very large field, but it can be done fairly easily in a plot of a few hundred square feet in area.

To determine the size of the seed plot it is necessary to know the amount of seed required the next year. For example if the requirement is fifty bushels then a plot giving about one hundred or more bushels. It is necessary to rogue diseased plants, cull diseased tubers at harvest time and make a rigorous selection in spring at seeding.. All these will reduce the available supply to about the amount required.

The use of such a seed plot should not do away with the necessity of spraying, but it would help.

Aside from the selection from a disease point of view, there is much to be gained in selecting for quality, purity of variety and yield. Such increase in quality and yield would more than pay for all the trouble expended.

The best cultural methods would have to be practised. A seed plot is a "spoilt child" in the bringing along of which one has to exercise all the supervision and protection possible. Roguing cannot be too severe and the plot should be changed and a long rotation practised to prevent the introduction of any disease.

I firmly believe that such methods would improve the crops in Quebec, I believe them to be possible of realization and think we should unite to urge the use of isolated seed plots.

THE RELATION OF INSECTS TO VEGETABLE SEED PRODUCTION.

R. C. Treherne, Entomological Branch, Dept. of Agriculture Ottawa.

When the question of pollination of plants is under discussion statements are usually based upon the conclusion that, generally, cross fertilization is beneficial to the species. It is usual to refer extensively to the value of insects in the act of cross pollination. A great deal has been written upon this subject and we have no doubts upon the matter that insects are essential to the satisfactory setting of fruits and seeds. In orchard work it is claimed that fully 99% of the cross fertilization is effected by insects and the same is very largely true with small fruits. It is only necessary to draw attention to the perfect and imperfect flowers of strawberry to appreciate the importance of this subject. It is, however, not my intention to enlarge upon this question at this time. Examples are available to every student, and nearly every practical horticulturist if he does not know the actual circumstances surrounding the crossing of plants at least appreciates the importance of plant and insect interdependence.

Today it occurred to me that a few remarks on the practical issues bearing upon the natural function of insects to the pollination of plants might not be out of place. The few remarks that I have to make refer to the question of seed production among vegetable crops. The notes that I have on this subject have been made up from some observations taken in British Columbia in 1918 while working on certain aspects of vegetable seed production—a project which received considerable impetus in that province about that time as a war measure. Just previous to 1918 the importance of producing home grown vegetable seeds became of consequence on the western coast. It was realized that the climatic and soil conditions were favorable to the production of vegetable seeds. A number of men were instrumental in placing this agricultural proposition before the farmers of the province. Mr. P. A. Boving, Professor of Agronomy at the University of British Columbia, Mr. Lionel Stevenson, at that time Superintendent of the Dominion Experimental Farm at Sydney, Mr. A. McMeans, Pacific Coast Representative of the Dominion Seed Branch, Mr. W. T. Hunter, of the Provincial Horticultural Staff, and Mr. L. E. Taylor, a practical fruit grower who became president of the B. C. Seed Growers Association, are all on record as favoring this industry. The prices to be received for home grown seed were favorable, while the prices to be paid for imported seeds were unfavourable, to say nothing of the dissatisfaction resulting from poor seed that was being used to some extent by the farmers of the province. With true western optimism a certain romance developed upon the possibility of developing a new agricultural industry and great endeavors took place at the time. While the leaders in the movement were fully aware of the difficulties and dangers of the situation based on the question of applied genetics, a surprising ignorance was shown by the average farmer in the matter of producing home grown seed. To many, all that appeared necessary was to select sound roots or plants such as cabbage, carrot, radish or onion, set them out in the spring and let them throw up seed heads from which a bountiful harvest of seed would be taken in the autumn. A good income of course would be expected. It was very interesting indeed to see some of these farmers' plantations in the year of 1918. Cabbages, turnips, swedes, beets, radishes, onion etc., were growing in great profusion, or, it might be better said, in great confusion, in rows, side by side, adjoining the farmers' outbuildings. Different varieties of these plants were to be found not only in a single acre but on neighboring farms, possibly in some cases only a few hundred yards away. All of this was essentially wrong and it was not surprising to find that when the growers experienced difficulties in the matter of seed registration their enthusiasm died down for the industry as a whole. Today I believe the same enthusiasm does not exist but as a result of the campaign that was conducted it was clearly shown that good seed could be produced, possessing high fertility and good germination. Soil and climatic factors were likewise favorable and it may be

truly said that if proper scientific study was given the question of vegetable seed production it could become a major agricultural industry. I presume that what applies to British Columbia in this connection might also apply to other areas in Canada. During the course of the campaign it became necessary to study insects that were visiting the vegetable seed heads to determine what insects were mainly instrumental in the carrying of pollen and how great a factor each respective insect was in this connection as a pollen carrier, and what were the distances of flight of the strongest fliers.

I have no intention of dealing with the pure plant breeder's point of view at this time, for the reason that my knowledge on the subject is too incomplete. It would not, however, be out of place to just briefly mention one or two fundamental ideas which bear upon the question of the insect's relation to seed production. In the first place I believe it is generally recognized that close botanical relations should not be planted together or in close proximity to each other. This applies just as much to plants of the same kind as it does to its varieties, in view of the fact that it is impossible to produce pure strains if more than one kind is in flower at the same time in the same immediate neighborhood. Mangels, for instance, do not unite with turnips, carrots, onions or parsnips but they will cross very readily with sugar mangels, garden beets and chard.

We accept the fact that floral parts are usually adapted for cross fertilization and the resulting progeny is stronger and more virile as the result of cross fertilization, but if cross fertilization fails self fertilization may occur. I believe it is usually considered that the seed yield is commonly decreased as the result of self fertilization. The common cabbage (*Brassica oleracea*) has been shown, for example, to be capable of producing a great quantity of seed capsules under either enclosed or open conditions but the actual quantity of seed produced is much greater in the latter case than in the former. Pollen prepotency, dominant and recessive characters, and such like questions are familiar subjects to the plant breeder. They account for decreased yields of seed and for the suppression or appearance of characters present in the parents. A field of French breakfast radishes will set a greater amount of seed if uninterrupted cross pollination is permitted. If a large number of other kinds of radishes, such as the White Icicle, are grown in the same field or in adjoining plantations the yield would not only depreciate but a great instability of characters would become apparent in the progeny. The same applies to mixed fields of drum-head and ball-head cabbages or any other crop where mixed varieties are planted. It is quite clear that should one engage in the production and sale of agricultural seed a good working knowledge of plant relationships and genetics is not only important but actually necessary. We are only concerned at this time, however, with the insect visitors to vegetable seed heads and it is on this subject that we will confine our remarks.

The study as we undertook it was really quite simple in as much as we only followed the idea of watching the plants closely for considerable periods at a time and noting the various insects which alighted upon the seed heads of the various crops. The specimens were also collected for later determination and percentages from captured material as well as from observational matter were built up. In the majority of cases the insects taken were examined under binoculars to determine whether or not pollen grains were adhering to their bodies. An endeavor was made also to conduct this work over a period of two or three months which meant that a certain number of days at periodic intervals were set apart for close observation while, on other days, only cursory observations were made. You will agree, of course, that this method was very haphazard but as it turned out we obtained the practical information which we were after. As you will see by the records that I propose to give you in a moment or two that the honey bee entered into the situation in every case and as the honey bee is not only the most diligent collector of pollen and nectar but also the strongest flier it practically eliminated all other insect visitors.

Mangels.

It has been stated by some authorities that the flowers of the field mangel is not visited by honey bees. This we can say is not correct. We must remember that the question of the available honey flow in a given district bears upon the point as to what insects visit flower heads of any particular kind. I do not doubt for a moment that if the country at any particular time of year is well supplied with flowering plants the honey bee would not be a factor in the pollination of mangels, but if the flow is light there is no question at all but that the honey bee will visit mangel heads. Over a period of two months the following average of insect visitors was determined.

Syrphids	64%
Solitary bees	17%
Hemiptera	8%
Honey bees	7%
Coleoptera	2%
Wasps	2%

We will have more to say upon the actual habits of these various insect in a moment or so.

Wind is a factor that must be considered in the carrying of mangel pollen just in the same way as wind is probably a prime factor in the carrying of corn pollen. Quite apart, therefore, from the question of insect visitors a proper regard must be taken of the question of prevailing winds when setting out fields of mangels for seed production. The flowers are small but they have

a remarkably sweet smell which apparently proves a strong attraction to syrphid flies. The honey bee you will notice, while an important factor is not a very great one with mangels. This would imply that mangels of different varieties could be planted closer together than many other plants such as, for instance, onions. With onions the honey bee over two months of July and August proved the greatest factor of all, as the following table will show.

JULY		AUGUST	
Honey bees	56%	Honey bees	80%
Solitary bees	24%	Fossorial Wasps	11%
Syrphids	13%	Solitary bees	7%
Bumble bees	6%	Syrphids	2%
Coleoptera	1%	Bumble bees	1%

Here we find that honey bees at all times greatly exceeded all other insects in numbers and activities. The onion produces flowers in great numbers upon a large compact, globular head. These flowers are largely self fertile, and strictly the honey bee is not an absolute requisite to the plant. The strong odor, however, must prove a great attraction. Unfortunately in this connection as with others in which note is taken of honey bees, I have no way of dealing accurately with the question of the desirable distances at which plantations should be separated. The apiculturists claim that when the honey flow is light honey bees will travel five miles for pasture. I do not imagine in a practical commercial way that it would be necessary to set onion plantations of different varieties five miles apart to ensure a pure strain of seed, although the danger of cross pollination might be present. We would doubtless not be far wide of the mark to estimate that a seed district of 2½ miles is sufficient to devote to the production of one kind of onion seed.

Carrots.

With carrots the following analysis was obtained which brings to our attention the importance of the honey bee at two different periods of the year. During July Coccinellids appeared in great number on the seed heads and honey bees were entirely absent; while in August the honey bee became the most important factor.

JULY		AUGUST	
Coccinellids	46%	Honey bees	26%
Hemiptera	19%	Syrphids	18%
Solitary bees	20%	Coccinellids	21%
Syrphids	7%	Solitary wapss	12%
Bumble bees	4%	Solitary bees	9%
Bombyliids	3%	Diptera (small)	9%
Tachinids	1%	Bumble bees	5%

In this case the activities of the Lady Bird beetles may be considered purely local and during the early part of the blooming period of carrots probably the solitary bees rank highest in importance, both from the standpoint of their habits and their strength of flight. Bumble bees while their percentage of prevalence was low, were very industrious throughout most of the season and, with the solitary bees, doubtless are the factors of most importance in the carrot seed area. I am informed from the writings of Prof. Boving and also from our general information on the subject that the different varieties of carrot cross readily among themselves and with the wild carrot, *Daucus carota*, the cross I believe resulting in a deterioration not only in color and shape but also in quality. The influence of the wild carrot is worthy of much consideration and attention must be given to the distribution of these wild plants in a carrot seed producing area. Their blossoming period coincides with that of the cultivated plants and extends over a greater part of the summer.

Sugar Beets.

With sugar beets we find that the Lady Bird beetles are again an important local factor, but solitary and social bees are probably the most important. As has already been pointed out the sugar beet is allied to the various mangel varieties and chard, and as the wind factor again enters the question, the same remarks as we made for mangels apply to sugar beets. The analysis over two months is as follows:

Coccinellids	32%
Syrphids	21%
Honey bees	20%
Solitary bees	14%
Hemiptera	13%

I have no records dealing with the insect visitors to swedes but, should this crop be grown for seed, we must not forget that swede varieties will not only intercross among themselves but they will mingle with turnips, rape and *Brassica campestris*. Prof. Boving has recorded an instance in Richmond County, P. Q., in 1915, where an examination of a field of swedes showed that the seed must have been very impure as the result of an examination that he made at that time. Fully 10% of the swedes showed excessively elongated necks, and at least 50% of the roots bore evidence of crossing in the abundance of prongs and crossing-lumps. In this instance the cross had been affected between swedes and *B. campestris* (Bird rape).

RADISHES

Mirids	34%
Diptera (small)	33%
Honey bee	22%
Coccinellids	5%
Bumble bees	4%
Asilids	1%
Pentatomids	1%

Parsnips.

With parsnips curiously enough the solitary bees prove the most important factor. Many of the species found were of large size and possessed considerable powers of flight. It is interesting to note in the analysis the attraction that parsnip flowers have for many insects which were not present in other seed heads.

Solitary bees	53%
Honey bees	13%
Mordellid beetles	10%
Solitary wasps	9%
Hemiptera	7%
Diptera (small)	6%
Syrphids, Coccinellids, Cerambycids	2%

I regret to say that I have no record on cabbages but I am sure that we may feel quite safe in assuming that the honey bee again is a factor in cross pollination of cabbage varieties.

Sufficient has been said, however, to show that plants of different varieties belonging to the same kind should not be planted close together or in the immediate neighborhood. I believe that it is usually considered essential that when commercial seed production is engaged in special seed districts must be formed. All that we have demonstrated as the result of the study of insect visitors to these plants is that the honey bee is a factor in each case and this being a fact these seed districts must be of sufficient size to obviate the danger of cross pollination. It would doubtless be necessary to create legislation establishing seed areas in which certain varieties only are planted and in which an earnest campaign for the destruction of allied weeds is undertaken. In every instance with the insects mentioned in this paper, pollen grains were found on the bodies. Syrphid flies were numerous and, as you doubtless know, are clothed with long dense hairs which are usually simple though frequently curved at the tip.. These hairs form an excellent trap for pollen grains. Some species such as *Eristalis tenax* have compound branching hairs. Their movements on the wing and on the flowers are erratic standing while on the wing over selected blossons before settling. Many members of this group are strong and active in flight and doubtless cover considerable distances, but their method of blossom visitation is not systematic enough to cause them to be of great concern to plant breeders. Adults may be seen frequently freely visiting plant after plant in a single stand but have been observed to visit, just as freely, plants in bloom of different botanical families in the immediate neighborhood. They do not hesitate after visiting the blossom of a plant to settle on the leaves of neighboring plants which excrete sweet exudations. Currant leaves appear to prove a strong attraction and

they may be frequently seen passing backwards and forwards from a vegetable seed plantation to the leaves of neighboring currant bushes. Many of the species noted, furthermore, were aphidaphagous,—their larvae living among the colonies of aphids—and adults passed quite readily from the blossoms of plants to colonies of aphids on the twigs of apple or on the leaves of cabbages.

The food of Syrphids consists primarily of pollen grains, although they seek nectar to a considerable extent. The Muscids, likewise, seek nectar and pollen and the vestiture of these flies is sufficiently long and dense to permit the ready carrying of pollen grains. However, it is my belief that pollination is more usually affected through the mouth parts. Their habits of blossom visitation are like the Syrphid flies—somewhat spasmodic. Soldier flies or the *Stratiomyiidæ* are strictly flowerloving insects and many species may be taken on the blossoms of vegetables. The size of individual species varies considerably as do their powers of flight. They are probably of more importance than the two families already mentioned as plant pollinators. The Bee flies or *Bombyliidæ* are usually heavily clothed with a vestiture similar to that of bumble bees. Their hairs are long and rigid and project straight out from the body. Their mouth parts, however, are extended and this fact does not force them to burrow deeply into the blossoms in order to obtain nectar. They are erratic on flight and frequently dart considerable distances; their habits are most interesting. It is not unusual to see them hover over a blossom and after extracting the food they require, dart perhaps ten or fifteen or more yards before they visit the next flower. Pollination with these insects is doubtless purely accidental but their remarkable habits in flight doubtless place them in the forefront of local pollinating agencies. The Sarcophagids Dexiids and Tachinids are also of importance as pollen carriers but their influence is purely local and other flies such as Therevids, Dolichopodids, Anthomyiids, Ortalids and Conopids are not great factors. Their legs and bodies are not heavily clothed with hairs and while they may carry pollen, their influence is practically negligible. Among the Hymenoptera the honey bee, the bumble bee, solitary bees and wasps rank very high.

It will not be necessary to detail the structure of these insects demonstrating their effectiveness as pollen carriers. That subject has been dealt with extensively on many occasions. Among beetles we find many species that feed on pollen. They do not move rapidly from plant to plant except possibly in the case of the Cerambycids. Usually beetles found in the seed heads will remain on the same head for hours on end and naturally are considerable factors in the carrying of pollen from blossom to blossom in closely compacted seed heads. The roughened portions of their body, the small projections, the minute hairs, enable pollen to be transferred form place to place. With these few remarks I will close the subject.

There is perhaps one other thought that might be dealt with and that relates to the economic control of insects affecting vegetable crops in general. The work of the entomologist has developed certain recognized control operations which in the majority of cases are proving satisfactory and economical. One must always bear in mind, however, that the control of vegetable insect pests has to be cheap enough to be brought within the economics of crop production. This is not always possible. I think it would be no harm to draw attention to that aspect of insect control which has to do with the improvement of vegetable strains. A sound healthy plant growing from a sound healthy seed is better able to produce economic commercial returns than a plant growing from poor seeds low in vitality. For instance, in a field of turnips being grown for cattle feed the treatment of such a field with mercury bichloride would probably cost more than the plants were worth and in the majority of cases it would not be practicable to pursue control measures with insecticides. As the result of some practical experience in this very connection which I had once in a dairy section in the Lower Fraser Valley of B. C., it was found that the degree of seeding obviated the danger of severe attack by the cabbage root maggot. With plants which germinated at the rate of between fifty and seventy to the linear foot of row, the degree of injury was not as great as when the young seedlings appeared at the rate of between twenty and thirty. The larvae of the cabbage root maggot as you doubtless are aware, move to some extent along the row attacking plants as they go. However, such larvae do not leave the plants until they have exhausted practically all available plant food. This period of migration which, of course, coincides with the period of spring oviposition, take place previous to the time of thinning the crop and the period of thinning usually coincides with the termination of the spring oviposition period. Hence the thinning operations leave the sound plants intact. If, therefore, turnip seed shows a high percentage of germination it is natural that the quality of seed bears very closely upon the economic control of the cabbage root maggot in field turnips. Exactly the same line of thought might be pursued with onions, where with heavy seeding followed by thinning good strong healthy plants obviate or outgrow the spring attack of the onion maggot.

The weight of heads and roots bears a close relationship to the strength of the seed and it is this point that I would refer to as it bears directly upon this question of plant pollination. There is no reason in the world why we should not develop our own home-grown seed industry. Usually such seeds are stronger when grown locally. They are suited to their environment and if we can guarantee their purity the resulting plants are obviously better and more worth growing. It is usually claimed, of course, that our costs of production for seed crops are too high to compete with Europeans. You are

perhaps better able to judge the truth of this than myself but I see no reason why efforts should not be made to bring into being an industry which would prove of great value to Canada where the soil and climatic factors in the majority of cases are essentially satisfactory.

The following list of representative Diptera is presented to record the types commonly met with.

Syrphidae.

Sphaerophoria cylindrica Say. off carrot, beet, parsnip, onion, Kelowna, Walhachin, Keremeos and Victoria, B. C.

Syritta pipiens Linn. off carrot, beet, onion, parsnip, Kelowna, Walhachin Summerland and Victoria, B. C.

Syrphus ribesii Linn. off carrot, beet, onion, Kelowna, Keremeos, Walhachin, and Victoria, B. C.

Syrphus (*Lasiopthicus*) *pyrastri* Linn. off carrot, onion, beet, Kelowna, Walhachin and Victoria B. C.

Syrphus americanus Wied, off beet, Victoria, B. C.

Syrphus opinator O. S. off mangel, beet, Victoria, B. C.

Helophilus chrysostomas Wied...off beet, Kelowna. B. C.

Helophilus latifrons Lw. off beet, Kelowna, B. C.

Eupeodes volucris O. S. off carrot, Walhachin, Victoria, B. C.

Tropidia quadrata Say off carrot, Kelowna, B. C.

Eristalis arbustorum Osborn off carrot, Walhachin B. C.

Eristalis occidentalis Will, off beet, Victoria, B. C.

Eristalis meigeni Wied. off carrot, onion, Kelowna, Walhachin, B. C.

Eristalis inornatus Lw. off carrot, parsnip, Kelowan, Victoria, B. C.

Eristalis tenax Linn. off carrot, parsnip, beet, Victoria, B. C., Walhachin, B. C.

Paragus bicolor Fabr. off carrot Walhachin, B C

Pipiza pisticoides Will. off carrot, Walhachin, B. C.

Merodon equestris Fabr. off beet, Victoria, B. C.

Thevidae.

Psilocephala laevigata Lw. off carrot, Walhachin, B. C.

Dolichopodidae.

Psilopus pilicornis Ald. Kelowna, off carrot.

Bombyliidae.

Systoechus oreas O. S. off radish, Kelowna, B. C.

Anthrax lateralis Say. off carrot, Walhachin, B. C.

Anthrax hypomelas Macq. off carrot, Walhachin, B. C.

Tachinidae.

Phorantha occidentis Walk. off onion, carrot, Walhachin, B. C.

Senotainia trilineata V. d W. off carrot, Walhachin, B. C.

Senotainia rubriventris Mcq. off carrot, Walhachin, B. C.

Ocyptera dosiades Walk. off carrot, Kelowna, B. C.

Tachinamella Walk. off carrot, Walhachin, B. C.

Plagia americana W. off carrot, Walhachin, B. C.

Echinomyia algens Wied. off carrot, Victoria, B. C.

Dexiidae.

Myiocera cremides Walk. off onion, Walhachin, B. C.

Sarcophagidae.

Sarcophaga helicis Tns. off carrot, Kelowna, B. C.

Sarcophaga hunteri Hhg, off carrot, Walhachin, B. C.

Sarcophaga communis Park. off carrot, Walhachin, B. C.

Sarcophaga planifrons Ald. off carrot, Walhachin, B. C.

Sarcophaga pallinervis Thom. off beet, Walhachin, B. C.

Wohlfahrtia meigenii Sch. off carrot, onion, Walhachin, B. C.

Muscidae.

Morellia micans Macq. off carrot, Kelowna, B. C.

Pollenia rudis Fabr. off carrot, beet, Walhachin, B.C.

Musca domestica L. off carrot. Walhachin, B. C.

Anthomyiidae.

Limnophora narona Walk. off carrot, Walhachin, B. C.

Pegomyia ruficeps St. off carrot, Walhachin, B. C.

Phorbia cilicrura Rdi. off beet, carrot, Kelowna, Walhachin, B. C.

Ortalidae.

Tetanops aldrichi Hend, off carrot, Walhachin, B. C.

Anacampta latiuscula W. off beet, Vernon.

Conopidae.

Zodion fulvifrons Say. off carrot, Walhachin, B. C.

Occemyia loraria W. off carrot, Walhachin, B. C.

Stratiomyidae.

Nemotelus arator Mel. off carrot, Walhachin, B. C.

Macrosargus viridis Say. off beet, Kelowna, B. C.

Stratiomyia norma Wd. off beet, Kelowna, Bl C.

—	Mangels %	Onions %		Carrots %		Sugar beets %	Radish %	Parsnips %
		July 13	August 2	July 7	August 18			
Syrphids.....	64					21		
Solitary bees.	17	24	7	20	9	14		53
Hemiptera...	8			19		13	35	7
Honey bees..	7	56	80		26	20	22	13
Coleoptera...	2	1						
Wasps.....	2		11		12			9
Bumble Bees.		6	1	4	5		4	
Coccinellids...				46	21	32	5	10
Bombyliids...				3				
Tachinids....				1				
Small Diptera.					9		33	6
Asilids.....							1	
Cerambycids.								2

A STUDY IN DISEASE SUSCEPTIBILITY.

Dr. B. T. Dickson, Macdonald College, Que.

The photograph in Plate 1 was taken in the experimental greenhouses of Macdonald College on February 10th, 1923. The plants in the bed were being used in a study of tobacco mosaic and all but two were inoculated successfully in October, 1922, with mosaic. The usual symptoms appeared as the plants developed until November 27th, 1922. On that day numerous small spots appeared in several lower leaves of mosaic-diseased plants. The spots were at first watersoaked, and about pin-head in size. They rapidly turned dark brown and eventually became almost white. In many instances zonation showed and on some leaves lesions coalesced between the larger veins. The disease spread as a result of the spraying and splashing of water from diseased leaves on other leaves of mosaic-diseased plants. In spite of continued attempts under ideal moisture conditions, no lesion appeared in any leaf of a healthy plant. It was at first thought to be wildfire from its symptoms but cultures gave only a micrococcus. Further study is being made of the disease, by T. G. Major, M.Sc., the Tobacco Pathologist of the Tobacco division Central Experimental Farm, Ottawa, in co-operation with the writer.

Several points of interest are to be noted in the photograph. The dwarfing of the mosaic-diseased plants is well shown. The two healthy plants are 2½ feet taller than the top of the photograph i. e. they are twice as tall as, and with correspondingly larger leaves than, the diseased plants. Their unspotted condition is marked in the two lower leaves, showing among the diseased plants. The fact that healthy seedling are not affected is indicated in the two pot plants in the foreground. Mosaic symptoms can be seen in many of the leaves of affected plants.

The photograph is by Mr. H. R. Angell, a plant pathology student of Macdonald College.

Contribution No 16, Dept. of Botany, Macdonald College, Que.

Plate I

THE NATURAL CONTROL OF THE GREEN APPLE BUG

(Lygus communis var. novascotiensis Knight) by a New Species of Empusa

By Alan G. Dustan, Assistant Entomologist, Dominion Entomological Laboratory, Fredericton, N. B.

The study which forms the basis of this paper was commenced in the sume mer of 1920 in the Annapolis Valley, N. S. At the time the Green Apple Bug was doing an immense amount of damage to the orchards in that section- in fact in a great number of the orchards the crops was being entirely wiped out each year by the ravages of this pest. A great deal of work had already been done along the line of artificial control but up until that year no natural control studies had been made and it was with a view to finding out what natural enemies the Green Apple Bug had preying upon it, and in the hope of being able to increase the efficiency of these parasites, that this work was under taken.

In order that what follows may be more clearly understood, a brief summary of the life history of the insect host is given.

The Green Apple Bug, as the name implies, is a small, green, Hemipterous insect, belonging to the family Miridae, which feeds for the most part on the blos soms, foliage and fruit of the apple.

In the spring when the blossom buds are beginning to show pink, usually about the last week in May, the nymphs begin to emerge. They are very tiny in this stage and pale-yellow in color. From the first they are extremely active and are able to run about on the twigs at a surprisingly rapid rate. As soon as they leave the egg they hide inside the blossoms where they feed, sucking the juice out of the opening buds and causing them to drop in great numbers. The nymphs turn green in color and are extremely difficult to see due to their habit of hiding under the leaves and in the blossoms. They grow and develop very rapidly and about a month after hatching reach the adult stage, when they are able to fly for considerable distances. In average seasons the first adults appear about the first week in July.

Mating takes place soon after the winged stage is reached. The females begin to lay their eggs during the latter part of July and, in some cases, continue the process right through the following month. The eggs are laid principally on apple trees, being deposited in the cambium layer of the twigs, chiefly on Gravensteins, Golden Russets, Nonpareil and Ben Davis varieties. There is

but one generation a year in Nova Scotia, these eggs hatching the following season, as has been already indicated.

Natural Enemies

This study has now been carried over two entire seasons and all investigations have shown quite clearly that the Green Apple Bug is almost entirely free from the attack of predators and insect parasites. A few of the nymphs are captured by ants and spiders but their great agility seems to safeguard them pretty thoroughly from the attack of all predators. Egg parasites of all kinds are wholly lacking, as are insect parasites in the nymphal instars and as a result the nymphs reach the last stage of their development practically unchecked. If all of these were able to develop into adults and deposit eggs, an enormous increase would result; but a very important control in the form of a fungous disease causes a large mortality in the last nymphal and adult stages, thus bringing about a very material decraese in the number of the adults before oviposition takes place. This fungus, which has proved itself capable of developing equally well in dry or wet seasons, has been of inestimable value to the orchardists and is rapidly causing the Green Apple Bug to disappear from the Annapolis Valley.

Life History and Development of Empusa nov. sp.

This organism, which proves to be a new and undescribed species of Empusa, passes the winter in the resting spore stage. These spores are found in the form of a dense envelope adhering to, and partially surrounding, the abdomens of diseased adults, which lie hidden away under the loose bark scales on the upper limbs of apple trees.

In the spring about the time the Green Apple Bug nymphs emerge each resting spore gives rise to a minute germ tube which develops into a small conidiophore, bearing on its tip a tiny conidium. In the vicinity of Wolfville the period of germination extends over at least forty days, which should be representative of conditions throughout the Valley.

When fully formed, these tiny spores are shot out from under the bark and float around in the air currents until they come in contract with a newly emerged nymph. They then germinate and a germ tube grows into the body of the insect, either through one of the spiracles or else directly through the integument at a point where it is thin, possibly between the body segments or leg joints. Once inside the nymph, the fungus commences to grow, not in

the usual manner by means of hyphal threads, but by a peculiar budding process in which socalled hyphal bodies are produced. These hyphal bodies are comparatively large, irregular fragments of mycelium, which at first float around in the blood of the insect where they rapidly increase in size.

Strangely enough, the fungus does not penetrate the thorax, for even when fully mature it still confines itself wholly to the abdomen. Just how long it takes the fungus to develop has not been learned but gradually the abdominal tissues begin to disappear, due to the action of the disease, and the number of hyphal bodies become proportionately greater. This increase goes on until the abdomen commences to swell and when development has progressed somewhat further, the whole dorsum bursts open.

Before this takes place, however, a change occurs within the insect. The hyphal bodies, instead of growing in their customary manner by budding, each send out a very stout tube which grows rapidly upward toward the back, of the insect and develops into a large club-shaped conidiophore. Hundreds of these are produced in a single insect, so that when the dorsum ruptures a flat, continuous layer is exposed which is formed by the tips of these uprightly growing conidiophores. This layer is in turn covered by a layer of hyalin mucilaginous material, closely resembling protoplasm.

At this point in the development of the fungus the majority of the Green Apple Bugs have reached the adult stage, although a few are still in the last nymphal instar, and as a result, most of the dorsally ruptured insects are winged forms. Due to the fact that the fungus has confined itself to the abdomen, the thoracic muscles of the diseased insects are still quite capable of functioning. As a result, the dorsally ruptured insects are able to move about the foliage quite easily and it is not an uncommon sight to see a nymph or adult walking over the infested trees trailing behind it a ruptured and frightfully mutilated abdomen. This retained power of locomotion helps greatly in scattering the spores and spreading the disease more widely.

When mature, the conidia are shot off into the air, each being surrounded by a mass of mucilaginous material which no doubt serves the dual purpose of protecting the spores from drying as well as aiding them in sticking to any surface with which they come in contact. If they a light on an unfavorable situation, secondary conidia are produced which are smaller and more oval than the primary ones and are in turn shot off into the air.

If the conidia alight on an adult Green Apple Bug, germination takes place and a germ tube grows into the body of the insect in the manner described. Up to a certain point the development of the fungus in this stage is quite similar to that found in the nymphs in the early part of the season. Hyphal bodies appear and grow freely in the abdomen of the host though in no other part, increasing in size and number very rapidly.

Apparently hyphal bodies from adults infected later in the season are quite similar in size and shape to those found in the nymphs in the spring, for careful comparisons were made and no differences could be found.

Growth of the hyphal bodies goes on until the abdomen of the host becomes completely filled. But now, instead of conidiophores being formed, resting spores are produced. This is done in a rather remarkable way. Up to this time the hyphal bodies had been very irregular in shape, varying from rounded or oval forms through all gradations to the most bizarre structures, many of which had long protuberances, giving them more or less of an amoeboid form. At this stage, however, a change takes place; the hyphal bodies become less irregular and more rounded in form and the contained protoplasm grows denser and to a large extent loses its vacuoles. Each hyphal body gives rise to a stout germ tube which gradually increases in length and finally grows through the integuments of the insect. During this growth the contents of the old hyphal body migrates into the tube and follows the growing point so that when the fungus bursts through the integument, all the protoplasm is collected at the tip. This apical portion now begins to swell and soon a rounded, globose body forms into which all the contents of the tube flows. The walls of this structure gradually thicken and in this way the resting spores are formed outside the body of the insect, though really adhering quite closely to it. As far as can be learned, these spores are asexually formed and hence are azygospores.

About the time the hyphal bodies are commencing to lose their irregular form, the adults become very restless and wander over the tress in search of a place in which to hide. They soon crawl away out of sight under some loose piece of bark and there die very quickly. After the death of the host the fungus goes on developing until the resting spores are formed, by which means the disease is carried over the winter.

Artificial Spread.

As has already been stated, the main object of this study on the natural control of the Green Apple Bug was first to find out what parasites were attacking this insect and then to make every effort to increase their effectiveness.

With this end in view, a detailed study of this new Empusa was made both in the laboratory and the field, to see if it was not possible to make the disease more generally useful in checking outbreaks and to find out whether it was possible or not to spread it artificially into localities where it was not already present.

In the laboratory every effort was made to grow the fungus on artificia media but without results. Resting spores, primary and secondary conidia,

as well as hyphal bodies from both the conidial and resting spore stages were experimented with at different times and in a number of different media, but no success followed these efforts. Although this was not altogether a surprise, still, it was disappointing as it was hoped that it might be possible to grow conidia artificially and spray them on the insects in the field.

When it was found that such a method was impossible, a study of the disease was commenced in the field to see if the fungus could not be spread by transferring diseased insects in different stages from one orchard or from one locality to another. This work has been carried on over two summers and it can be said now quite safely that the fungus can be spread, and has been spread, artificially very successfully from orchard to orchard. It also seems quite probable that by the same methods it will be possible to transfer the fungus from one locality to another. This will be tried out next summer for the first time.

In regard to methods, it has been found that there are three ways in which the fungus may be spread. These will be taken up separately and described in more or less detail.

Methods No. 1: Undoubtedly the best method so far tested out is the one in which freshly-ruptured insects, which are actively discharging spores, are transferred from an infected orchard into one showing no signs of the disease. Several orchards have been treated in this way and good results have always followed. The conidia discharged from the introduced insects infect the adults with the result that an outbreak of the disease takes place and a large number of bugs crawl away under the bark where resting spores are produced. In the spring these germinate in the manner already described and the emerging nymphs are attacked by the fungus.

In carrying out this experiment care must be taken to gather the ruptured insects while fresh. This can be done to best advantage early in the morning when the dew is still on the tress. Also best results followed when the diseased forms were introduced into heavily infested orchards, for the heavier was the infestation, the faster did the epidemic spread.

Methods No. 2: In the late summer when all the Green Apple Bugs have reached the adult stage one often sees in orchards where the disease is present numbers of these insects scurrying around on the larger branches, apparently looking for a convenient place in which to hide. These are diseased forms in search of secluded spots where they may crawl away and die. If a number of such insects are captured while still alive and introducted into an orchard, they quickly find shelter underneath the bark of these trees. Here the resting spores are formed and in the spring primary infection of the young nymphs takes place through conidia arising from this source. As many diseased

adults as possible should be transferred at one time and best results have been obtained where they are all placed on one heavily infested tree situated in a central part of the orchard.

Methads No. 3: The third method of artificially introducing the disease into an orchard is practised in the spring before the blossoms unfold. This consists in transferring the resting spores from one orchard to another. The best way in which to do this is to gather the loose pieces of bark, under which the resting spores pass the winter and to which they closely adhere, and by means of tacks attach them to the upper limbs of the trees to be infected. Care should be taken to fasten the bark scales so as to have the surface on which the spores are born next to the tree and not directed away from it. As in the previous method a large number of spores must be transferred and they should be concentrated on one central tree in the orchard under treatment.

Economic Importance of the Fungus.

In Nova Scotia the Green Apple Bug is a comparatively new pest, having been noticed for the first time in June, 1914, but notwithstanding that fact it is now considered one of the worst, if not the worst, insect with which the orchardist has to contend. Speaking of the seriousness of this pest Dr. W. H. Brittain in his bulletin entitled "The Green Apple Bug in Nova Scotia" (Bull. No. 8, N. S. Dept. Agric.) says, "The apple crop in the Annapolis Valley has not been increasing at the rate one would expect from the new acreage constantly reaching bearing age each year. On the contrary, it seems to have, on the whole, actually gone back. There is little doubt in the mind of the writer that this condition of affairs can to a large extent be laid at the door of the Green Apple Bug."

Since the publication of the above-mentioned bulletin (1917) this insect has been gradually decreasing, not only in the sprayed orchards but just as rapidly in the untreated ones. At that time investigators working on the artificial control of the bug were at a loss to account for this strange and unprecedented numerical reduction. Since the discovery of the fungus in 1920, however, the problem has become clear, for it seems quite certain now that the disappearance of the Green Apple Bug was due wholly to the work of this fungal parasite. Studies carried on subsequent to the discovery of the disease have shown that the insect is still decreasing and that the decrease is being brought about by the Empusa in question, which goes to prove the truth of the above theory. With such an important natural control factor availeble and one amenable to artificial dissemination, it seems safe to predict that the Green Apple Bug will never again be as serious a pest in the Annapolis valley as it has been in the past.

PEONY DISEASES

by J. G. Coulson

The peony is one of the important economic ornamental plants and some growers have a good deal of capital invested in them. Very little has been written concerning the diseases of the peony and it is for the most part considered to be a sturdy perennial plant remarkably free from all such troubles, but a little observation any season will show that the different varieties are more or less subject to quite a number of diseases. The amount of infection undoubtedly will be found to vary a good deal, depending upon the season and other conditions, but during the last two summers that the diseases of this plant have been under observation at Macdonald College most varieties have shown severe infections. Last summer we received several inquiries concerning diseased conditions of peony plants and this with our own observations would lead us to believe that disease is quite general in Quebec and Ontario.

Saccardo lists 42 fungi found upon the peony. These may be grouped as follows:

On living leaves	18.
On living stems	5.
On leaving leaves and stems	2.
On fruits	1.
On underground parts	1.
On dying leaves	3.
On dead parts	12.

This gives a total of thirty fungi found upon living parts of the plant and we may conclude that at least the large majority are disease producing. There is no reason to believe that this list should include all the fungi which cause disease in the peony. Our work which was begun a year ago this fall (1921) at the suggestion of Dr. Dickson has shown the peony to be subject to at least seven different distinct diseases. These will now in turn be briefly described. The first two diseases have been known for a long time and will merely be mentioned.

1. Botrytis blight—(*Botrytis Pœoniæ Oud*).

This is generally considered to be the most trouble some and most common disease of the peony and is well known to everyone as producing "blasted" or brown and unexpanded buds, or large dead spots upon leaves and stems.

2. Cladosporium leaf blotch—(*Cladosporium Pœoniæ Pass.*)

This produces large blotches, purple above and chestnut-brown below, upon the leaves. Estimated infection for all varieties 5%.

3. Septorial leaf spot—(*Septoria pœoniæ West var. berolinensis Allesch.*)

This undoubtedly is a very troublesome disease of the peony, affecting both leaves and stems and was first noted at Macdonald College in Aug., 1920, The amount of infection upon the leaves ranged from 0 to 85% on different varieties, and the average for all varieties, was estimated at 20% for the fall of 1921 and 1922. Usually where heavy leaf infection occurred severe stem infection was also found. The spots on the leaves are small, limited by veins more or less round, yellowish-brown, with pale or ashen gray centres, purple bordered and usually showing zonation. The centre is usually somewhat sunken, shows a tendency to drop out and when this happens various Alternarias' are invariably found in the spots. On the stems the spots are whitish purple-bordered and tend to become elongated.

Last spring this disease was first observed upon the young stems of a few plants on the 10th of June, and was the first disease to make its appearance. From the stem it spreads to the leaves, first infecting the leaves toward the interior of the plant due to moist conditions prevailing there. This as well as other diseases spread very rapidly during the rest of June, and the first half of July during which period there was a good deal of rain. From this time very little new infection occurred until the middle of September following a period of considerable rain.

The spores are produced in brown gregarious pycnidia with a distinct ostiolum. They are described by Saccardo as being fusiform, curved, accuminate at both ends, indistinctly multinucleated, hyaline 25—30 = 1½—20.

Spores can be found in quite young lesions and in great numbers and it was quite easy to isolate the fungus in pure culture. This is the second time that this fungus has been reported for America, it being first reported by Anna E. Jenkins in Pathological Herbarium Notes issued by the United States Dept. of Agriculture, Bur. of Plant Industry. No. 2, Sept. 1st, 1921. This fungus has been isolated and infection experiments and further studies will be carried out this winter .

4. "Mosaic" disease.

This is found upon a few varieties, but cannot be considered to be a troublesome disease.

5. Two leaf spots of unknown cause.

(a) A disease characterized by irregular lead-white spots with a comparatively broad purple border. These spots are for the most part confined to the upper surfaces of the leaves and do not show or only slightly on the under surfaces. When showing through the under surface they appear as light brown spots. Scattered, black, more or less erumpent pycnidia or peritheria

can be found on many of these lesions. Examination has shown these fruiting structures to belong to Phyllosticta, Pleospora, Septoria, and possibly one or two other genera. An undetermined Phyllosticta is, however, most commonly associated with this disease. Various fungi have been isolated in pure cultures from these spots and inoculation experiments will be carried out.

This disease was first noticed on the 26th of July. It did not increase very rapidly and the amount of leaf infection this fall was estimated at 2%. See fig. I.

(b) Another leaf disease characterized by definitely limited irregular, yellow spots with a dark border in most cases was quite common on a few varieties. The spots vary from 2 to 8 mm. broad.

The fungus most consistantly associated with this disease is a species of Alternaria. This has been isolated and artificial inoculations were carried out last winter upon two plants in the green house and again last spring upon plants in the field. By keeping the plants under bell jars for two or three days after the inoculum was applied, it was quite easy to get infections and typical spots begin to develop in four or five days. The inoculum used was a suspension of spores in distilled water applied as a spray or a portion of agar from a test tube culture with mycelium and spores placed upon the leaves. From most of the lesions so produced the Alternaria was again isolated in pure culture. This is quite strong proof of the pathogenicity of this fungus. As only two plants were available last winter, it was impossible to have sufficient controls to work with and the field inoculations are not considered to be too reliable as the plants may have been inoculated from some other source. With more plants in the green house available this winter it is hoped that we will be able to thoroughly establish proof of the pathogenicity of this fungus.

6. Disease of the underground parts.

A plot of peonies at Senneville last summer was very heavily infected with a disease of the underground parts which was confined chiefly to the roots. The plants were set out last spring on land which had been used for some time as a garden.

The tops showed a marked wilting and dying with a blackening of the stem passing upward from the ground. A number of plants produced new branches and leaves in the late summer or fall. The roots on plants in which the tops were dying or dead were themselves dead or dying. The entire underground portion was usually blackened to a considerable extent. It is believed to be a Fusarium root rot as growth of Fusarium could be found on most of the roots and this was isolated in pure culture.

Summary.

Peony plants in this district are subject to at least seven distinct diseases. The most troublesome disease being the Septorial leaf spot.

Contribution No. 17, Dept. of Botany, Macdonald College, Que.

Plate II.

FIG. 1.—This shows lesions believed to be caused by an undetermined *Phyllosticta*. The spot at A is very typical. The others are somewhat larger and more irregular than usual. The spots developed in the field after a moist period o some days and this perhaps accounts for their large size.

FIG. 2.—A close up view of the Septoria spots included in the outlined area in Fig. 3.

Plate III.

FIG. 3.—A leaf infected with *Septoria paeoniae var berolinensis.*

FIG. 4.—A plant with a disease of underground parts and lower part of stem.

FIG. 5.—The same plant after it had been kept under a bell jar for some time showing the stem overgrown with a Fusarium.

FIG. 6.—Septoria spots on stem.

COMBINATIONS OF DUSTING AND SPRAYING MATERIALS.

by

George E. Sanders.

The reactions that take place between the various chemicals used in dusting and spraying are not as yet as thoroughly understood as they should be. In the short space allotted it is impossible to give more than a brief sketch of each beneficial or injurious reaction that has come to my notice and to outline a few of the desirable and undesirable combinations.

Copper Compounds.

One of the best known reactions is that of lime on copper sulphate in the making of Bordeaux. When just enough lime is added to a copper sulphate solution to neutralize it, we get a precipitate of basic copper sulphate. As more lime is added we get a series of double copper calcium sulphates, each more basic than the last. When around five parts of lime to one of copper

1.
2.

3.
4.
5
6

sulphate is added, we get copper hydrates formed. The curious thing about this reaction is that even when equal parts of lime and copper sulphate are present there is a great excess of free lime and as more lime is added more of the lime combined chemically with the copper. This reaction is important in that potatoes will stand basic sulphates and double basic sulphates, while apples demand that a portion at least of the copper be in the hydrate form. Hence the recommendation of excess lime Bordeaux or 3—10—50 for apple spraying. It has been found that magnesium lime has greater neutralizing power, or makes a safer Bordeaux, than high calcium lime.

Copper sulphate for use on ground crops such as potatoes may be combined with a number of basic salts, such as magnesium oxide, magnesium hydroxide, sodium carbonate, sodium hydrate, sodium silicate, potassium carbonate, fish oil soap or even free nicotine.

Copper Combinations with Arsenic.

It is not generally recognized that copper is a safer and more reliable neutralizer for soluble arsenic than is lime. The copper of Bordeaux reduces the killing value of arsenicals used with it by around 43 per cent. Almost any arsenical can be used in Bordeaux mixtures if the proper precautions are taken in combining it.

The most commonly used poison in Aroostook County, Maine, is arsenate of soda, which is sold under the name of arsenoid. The arsenate of soda is dissolved in water and added to the completed Bordeaux. The majority of the arsenate combines with the lime to form arsenate of lime, but a portion at least combines either wholly or partially with the copper.

The old "Kedzie" formula, which results in an arsenite of soda solution, is an excellent Bordeaux poison, but when added to the completed Bordeaux it frequently gave some burning on account of too great a proportion. If the arsenite of soda is poured into the copper sulphate solution and caused to form green arsenite of copper before the lime is added that burning is almost entirely eliminated.

D. E. L. Mixture is 50 per cent superfine dust collector white arsenic and 50 percent hydrated lime. The lime causes the arsenic to wet readily and when in solution the two combines to form what we think is acid arsenite of lime. If copper sulphate is dissolved into water containing this mixture, green cooper arsenite is formed and the stock solution of copper sulphate containing the green precipitate of copper arsenite may then be used in the regular way and combined with the proper quantity of lime to make Bordeaux. This is by all odds the cheapest Bordeaux poison on the market and it has been used successfully for three years now in New Brunswick and Nova Scotia.

Arsenate of lead is very widely used in Bordeaux mixture, the theory being that it is more adhesive than other poisons. The lime and the copper in Bordeaux break away two-fifths of the arsenate from ordinary hydrogen arsenate of lead to form either calcium arsenate or double copper calcium arsenate. The remainder forms basic lead arsenate. Lead arsenate is a very slow killer in Bordeaux. The sticking value of arsenate of lead in a Bordeaux is so surpassed by the superior sticking value of the Bordeaux itself as to make the sticking value of the arsenate of lead negligible in the combination.

Paris Green is still the favorite in many sections of the country as a Bordeaux poison. After all the trouble that the manufacturer has in forming a nice green copper aceto arsenite crystal, the Bordeaux extracts the acetic acid to form either calcium acetate or copper acetate and leaves arsenite the same as we get from pouring arsenite of soda into a copper sulphate solution.

Arsenate of lime is probably the ideal poison for use in Bordeaux. It is low in cost, the copper acts very slightly on it, if at all, and it should give as good or better killing than any other arsenate in Bordeaux.

Lime Sulphur and Arsenicals.

Lead Arsenate is the most popular poison in lime sulphur solution. We all know that a reaction takes place between the two. Various competent chemists have explained this reaction to us in various ways. We know that there is a reaction. If we puddle our lead arsenate with calcium caseinate we reduce this reaction. If we puddle our lead arsenate with lime we do the same. We do not know if an excess of lime is desirable in lime sulphur since after a short time we have to depend on the SO_2 formed from precipitated sulphur as our fungicide, and we would expect the excess of lime to neutralize this SO_2 and so reduce our fungicidal value.

Some arsenate of lead which contain certain spreaders, stickers, and suspending agents, react much more completely with lime sulphur solution than straight lead arsenate. Recent knowledge regarding the manufacture of calcium arsenate helps to explain this reaction.

Arsenate of lime has been quite widely used in lime sulphur and I believe that the time is coming when we will all be recommending arsenate of lime in lime sulphur, but our present arsenates of lime vary too much for this recommendation to be made at the present time. The addition of a couple of pounds of high calcium lime for each pound of arsenate of lime in lime sulphur makes it safe, but we are there up against the danger of cutting down the fungicidal value of our lime sulphur.

Sodium Polysulphide Combinations with Arsenic.

Lead arsenate cannot be used in sodium polysulphide solutions. Arsenate of lime has been used successfully with sodium polysulphide in the following:

1 lb. sodium polysulphide.
¾ lb. arsenate of lime.
5 lbs. high calcium hydrated lime.
50 gallons. water.

Dusting Sulphur.

Dusting sulphur depends for its fungicidal value on the $S02_2$ formed. Where the temperature gets very high, $S0_2$ may be formed so rapidly as to cause burning. Where the temperature is very low $S0_2$ may be formed too slowly to set as an efficient fungicide. This defect of sulphur dust often shows up in the control of apple scab which is a cool weather disease. The value of sulphur dust depends largely on the temperature and the uneven results following its use as compared with the more even results of copper are thus explained. In very hot climates, where there is danger of sulphur dust burning, the use of ten or fifteen per cent of lime is necessary. In cool climates the use of lime in sulphur dust is a detriment as it neutralizes the $S0_2$ as rapidly as it is formed and reduces the fungicidal value too much.

Sulphur Dust and Arsenicals.

Lead Arsenate is the standard poison for use in sulphur dust. Arsenate of lime is too cautic for use on foliage, even when diluted with sulphur. In spite of this, arsenate of lime is being successfully used with sulphur in certain localities.

Red arsenic, or realgar or arsenic tersulphide, is insoluble in acids and solu ble in alkalis. Red arsenic has been used with safety in pure dusting sulphur- but is too heavy and dense for a good dusting material.

Copper and Sulphur Cominations.

It has always been assumed that copper and sulphur neutralized each other completely. There is now some question as to the accuracy of this. How-- ever, it is safe to say that the use of copper and sulphur mixed in dusting materials is undesirable and wasteful, although the status of copper sulphide and copper sulphite as fungicides is yet to be established.

Nicotine Combinations.

If we pour free nicotine into a copper sulphate solution we get a blue nicotine Bordeaux. Just what the status of copper nicotine sulphate is as a contact insecticide, I am not prepared to say, but I do know that such a compound is highly undesirable in a nicotine dust where the volatile nicotine only is of value.

The presence of dehydrated copper sulphate in a nicotine dust cuts down the volatility of the nicotine by about one-third. In the same way the presence of acid lead arsenate reduces the volatility of the nicotine. The presence of organic matter or the presence of moisture also retards the volatility of nicotine. The making of nicotine dusts is a very particular operation and for the greatest economy and efficiency only straight nicotine dusts should be used. "Three in One" and "All in One" dusts mixtures are inefficient, costly and undesirable.

Copper Arsenic Dusts.

Three types of copper dusts, in addition to the dried Bordeaux powder that has been offered for so many years, are now being offered.

Blue Copper Arsenic Dust.

This dust is made up of monohydrated copper sulphate, hydrated lime and arsenate of lime. It is called Blue dust on account of it turning blue when brought in contact with water. It is when applied merely a mechanical mixture of the three ingredients, combination taking place or Bordeaux salts being formed when the material comes in contact with moisture on the plant leaves. While this material is light and fluffy the active ingredients in it will only pass a 200—mesh screen.

The high limits of a 200-mesh, monohydrated copper sulphate in this type of dust are 35 per cent on the potato and 20 per cent on the apple. By using magnesium hydrated lime and getting the copper sulphate ground extra fine a higher percentage of copper sulphate be used with safety. In practice I do not find it advisable to go beyond 25 per cent of monohydrated copper sulphate for the potato and 15 per cent of monohydrated copper sulphate for the apple in this type of dust.

Lead arsenate has been used by us in this type of dust and is insisted upon by some experimenters. Lead arsenate increases the cost and does not seem to me any more desirable as compared with arsenate of lime than it is in liquid Bordeaux.

Superfine dust collector white arsenic was used by me in this type in my own orchard one season with no injury. Mr. Kelsall used it in his orchard with

the result that he got some leaf injury. There is just a possibility that white arsenic might be used in this type of dust on potatoes to good advantage. Extreme care would have to be taken in having the same white arsenic from the same source used every year, for white arsenic is one of our most variable products so far as its reactions go.

Brown Copper Arsenic Dusts.

This dust is made up of arsenic acid, crystal copper sulphate, burned lime and water. The heat of the slaking lime is utilized to convert the arsenic acid. into arsenate of lime and to cause the copper to be dehydrated and combined as double basic sulphates. This dust is being sold entirely for apple work this season in the proportions of 18 pounds of crystal copper sulphate, 8 pounds of arsenate of lime and the remainder, to make up 100 pounds, hydrated lime. This dust is not so easy to grind or so fine as the Green Copper Arsenic dust, which follows.

Green Copper Arsenic Dust.

This dust is the lowest priced of all dusting materials. It is made up of white arsenic, crystal copper sulphate, burned lime and water. As in the last, the heat of the slaking lime is utilized, but the arsenic is caused to combine with the copper, forming double copper calcium arsenite. This dust is made for the potato in the formula of 9 per cent metallic copper and 5 per cent metallic arsenic, or the equivalent of 36 per cent of crystal copper sulphate and killing value in arsenite form equal to 25 per cent of arsenate of lead. This dust is being sold for less money than the average farmer can purchase equivalent values in crystal copper sulphate, arsenate of lead and lime for making up liquid Bordeaux thus making dusting materials, for the first time, cheaper than equivalent, materials for liquid spraying.

The extreme friability of this type of dust makes it possible to pulverize it so that over 98 per cent will pass a screen of 325 meshes to the inch. The soluble arsenic in the 9-5 Green potato dust can be made 0.11 and the soluble arsenic in the 6-3 Green apple dust can be made 0.1 which is much lower than either crop demands for safety.

I have endeavored in this paper to give a brief resume only of the points that are now uppermost in combinations of copper, sulphur, arsenic and nicotine.

WHITE ARSENIC AS AN INSECTICIDE.

By G.E. Sanders.

In discussing the above it is difficult to say just where we shoud draw the line since practically all the arsenicals on the market today are made from white arsenic. In this paper I shall endeavor to confine myself to white arsenic itself and the materials or compounds that may be made from it by one single farm operation.

White arsenic is not by any means a standard article. It may vary in purity from 40 to 99 per cent pure. Even 99 per cent arsenic may contain enough impurities, which may be antimony, bismuth, lead, sodium, etc., to affect its behavior in most tantalizing ways. White arsenic as it is sublimed varies in fineness from around 100 mesh to an impalpable powder. In a smelter where 90 per cent of the output runs 99 per cent pure with a fineness of around 150 to 200 meshes, the remaining 10 per cent will run from 90 to 96 per cent pure and for the most part go through a 300-mesh screen. It is this extremely fine dust collector arsenic that is from 3 to 9 per cent low in purity that I have found best adapted for direct use as an insecticide.

One of the most remarkable and tantalizing things about white arsenic is the remarkable effects that even small quantities of impurities have on its reactions which prevent an experimenter from saying, "A certain purity of white arsenic if ground to a certain fineness will do this or that". What it may or may not do depends on the impurities present which may speed up the reaction as in the case of sodium or slow it down as in the case of bismuth.This is the big objection to the use of formulas that allow the farmer to utilize raw white arsenic. Briefly, there are three uses to which white arsenic has been put directly, vix:

1. Dusting directly on potato Vines.
2. In Baits.
3. In Bordeaux Mixture.

1. Dusting Directly on Potato Vines.

Experiments on this were conducted by Cooley in Montana. It was reported that white arsenic was used directly and straight on potato vines in Montana with safety. The only details that I got from Professor Cooley were that a particularly pure and fine grade of white arsenic was used. In a dry climate like Montana and where the hot, sunny summers make the potato leaves very tough and where there is probably less ammonia in the air than in most potato sections, we would expect this. In addition, Professor Cooley may have happened to use a white arsenic that was not only low in sodium and potassium, but which contained some such impurity as bismuth.

I have used various grades of white arsenic on potatoes in Nova Scotia and the burning there from 99 per cent pure material was usually moderate to bad, say from 10 to 30 per cent of the leaf area destroyed. With dust collector arsenic, much finer material and only 90 to 96 percent pure, the burning was invariable severe. The addition of lime, particularly magnesium lime, greatly increased the burning.

I do not think that we can ever recommend generally even the most pure white arsenic for use straight on potatoes. It may be that some particular grade from certain ores may find a place in the drier sections of the northwest, but there I am quite sure that the source, the purity and the methods of refining would have to be watched too carefully to make it of safe, wide application.

2. In Baits.

For cutworm and grasshopper baits, white arsenic is ideal. Some years ago, J. J. Davis reported excellent results from a low grade white arsenic from one of the Western U. S. Smelters. In 1921, I corroborated Davis' work, using dust collector arsenic of much greater fineness than Davis had used. I found that one pound of dust collector arsenic, running 92 percent pure and of a fineness of 250 to 300 meshes to the inch, possessed greater killing value on grasshoppers than an equal weight of 99 percent pure material having a fineness of around 200 meshes. The higher solubility of the dust collector arsenic on account of the impurities in it and its greater fineness were both factors in causing it to be superior pound for pound to the purer material. I found dust collector white arsenic superior to all other materials tested for grasshopper baits. It is, of course, lower in cost than pure white arsenic and infinitely cheaper than Paris green.

We found the best and most economical bait formula to be:

5 lbs. dust collector arsenic.
10 lbs. salt.
100 lbs. bran.
Water to make a mash.

We could get no benefit from banana oil, fruits, fruit extracts or any other attractants. The great attractant in the locality in which I was experimenting, Manitoba, was water. Farther west, where the water was alkaline, Mr. Kelsall carried on numerous experiments in 1921 and there he got no appreciable benefit from salt. In Manitoba, where the water was sweet, I got a decided benefit from salt.

Paris green is, of course, a good poison in baits, but it causes more poisoning than white arsenic among the men in the mixing stations and is much more expensive.

White arsenic, particularly dust collector white arsenic or any low grade white arsenic, if ground to sufficient fineness, is superior to all finished arsenicals and to pure or 99 per cent white arsenic for grasshopper and cut worm baits.

3. In Bordeaux Mixture.

In 1917, under instructions from the late Dr. Hewitt, we started investigating the possibility of using white arsenic directly in Bordeaux mixture. When added directly to Bordeaux, white arsenic showed two serious defects. First it would not wet readily. Second, a portion of it combined with the lime to form, a very soluble arsenite of lime with the result that leaf injury was caused. Mr. Kelsall was with me at the Annapolis Royal Laboratory at the time and as one of us would give the problem up in disgust, the other would pick it up, add something to it and then give it up again, until we finally got a fairly practical method of using white arsenic in Bordeaux and a large number of farmers in New Brunswick used it.

The steps as I remember them, were as follows:—One of us by accident mixed some dust collector arsenic with hydrated lime and found that it would wet through quite readily and quickly. Next, one of us noticed that Bordeaux into which we had mixed this white arsenic hydrated lime mixture was turning color from a blue to a green on the leaves of the plants.. About this time we were beginning to realize that copper sulphate was of very much more value than lime in eliminating soluble arsenic. Then a long series of tests in the chemical laboratory followed and Mr. Kelsall announced that a good factory product could be made by our method, but that it was not yet fit for the use of farmers. It was then dropped for almost a year and then we developed what has proved a practical farm method. We prefer to use dust collector white arsenic of around 90 to 95 percent purity on account of its greater solubility, fineness and the speed with which it reacts. We mix equal parts of hydrated lime and white arsenic together and mix them in the water into which we intend to dissolve our copper sulphate. Then we hang a bag of copper sulphate in the top of the water and let it dissolve, stirring occasionally. After the bluestone dissolves, use in exactly the same manner as ordinary copper sulphate solution in combining with lime to make a Bordeaux. Use about 1½ lbs of dust collector arsenic and 1½ lbs of lime in the copper sulphate solution intended for an acre of potatoes.

The reaction that we suppose takes place is the formation of a very soluble arsenite of lime by the hydrated lime and white arsenic loosely combining and then as the copper sulphate dissolves the formation of copper calcium arsenites which give the green color to the solution and to the resultant Bordeaux. The arsenite resulting from this procedure is very gelatinous, very adhesive, and an excellent insecticide. We have found it absolutely safe and effective. It is true

that it adds to the trouble of making Bordeaux and that it is not so handy as arsenate of lime. On the other hand, it is very cheap and effective and, when properly made, safe on foliage. A large number of farmers in New Brunswick have been using this mixture for the past three years with good satisfaction. We named the mixture of hydrated lime and dust collector arsenic "D. E. L. Mixture", the initials of the Dominion Entomological Laboratory where we worked the formula out.

As I stated in the beginning, just where to begin and where to end in such a paper as this is debatable. White arsenic is the basis for practically all of our arsenicals, but practically all purposes other than the ones I have outlined call for one or more factory operations before white arsenic can be made useful.

I can see no large use for white arsenic direct with the exception of its use in baits, especially in view of the wonderful improvements that are now being made in the cost of manufacturing combined arsenicals and in the arsenicals themselves.

CULTURAL CHARACTERISTICS OF CERTAIN SPECIES OF FUSARIUM.

by T. G. Major, B. S. A., M. Sc.

In undertaking these investigations the object has been to study the reactions of a number of species of the genus Fusarium (Link), found in root lesions, when grown under various cultural conditions. The difficulty of identifying an organism, even in pure culture, with descriptions in the literature, is well known since the medium is but seldom mentioned, and frequently the same fungus grown on two different media exhibits very different types of growth. This variation involves not only the type, amount and rate of growth, and colour production, but also the presence or absence of spores, size of spores and other microscopic characters. The investigations, the results of which are here presented in an abridged form, had the main object of determining to what extent an organism varies under known cultural conditions, with a view to its classification. In preparing this paper it has been found necessary to leave out most of the detailed results and to present only the methods, in brief, and the general results and conclusions reached. The original work itself was very limited in its scope, owing to the time factor, and the conclusions drawn can, at the most, only be regarded as suggestive.

Contribution No. 18, Dept. of Botany, Macdonald College, Que., being an abridgment of a thesis submitted to the Graduate School of McGill University, in partial fulfillment of the requirements for the degree of M. Sc., 1922.

The genus Fusarium possesses certain characteristics which make it specially adapted to a study of this nature. There are a large number of species, (Saccardo lists 401), and they are widely distributed in the soil. The spore types are very characteristic and the genus possesses the power of chromogenesis to a marked degree. The genus also exhibits a wide variation in characters when grown on artificial media. In addition to these factors, a great deal of work has been done in recent years on the taxonomy and pathogenicity of the genus Above all, the Fusaria appear to be becoming of increasing importance as producers of disease in economic crops.

Scope of work.

The investigations have been carried out under three main heads:—

1. The determination of a number of species of Fusarium isolated from various sources;
2. The study of their growth on various media;
3. The study of their growth at different concentrations of the hydrogen-ions in the media.

In determining the species the literature chiefly relied upon has been the classic monograph of Appel and Wollenweber (1: 1910), subsequent articles by Wollenweber (16: 1913), Sherbakoff's work on the potato Fusaria (12: 1915), and subsequent articles, based on these, by other investigators. Exact identification was not found possible in every case and in such an instance the species with which the organism most closely agrees is given. The growth characteristics of the various organisms isolated have been studied on as wide a range of media as possible, and observations made on the effect of tempareture. Detailed descriptions of the macroscopic and microscopic characters were made and from these observations certain tentative conclusions have been drawn. In order to secure data in regard to the effect of various concentrations of the hydrogen-ions in the media, a series of cultures were grown on media standardized to different Ph values. The colorimetric method of Ph determination described by Clarke and Lubs (5: 1917) and more fully by Clarke (4: 1921) was used.

Culture media.

In all, seventeen different media were utilized and they may be grouped under two main heads, namely, natural and synthetic. The first group consists chiefly of plant media, either in the form of steamed plugs or combined with agar. In the second group are a number of well known nutrient solutions, both in the liquid form and combined with agar. The media used are as follows:

1. Natural—(a) without agar—string beans, raspberry cane, potato, white carrot plugs and steamed rice.
   (b) with agar—iris leaf juice, potato juice, bean, and soil solution agars.
2. Synthetic.(a) without agar—Uschinsky's, Richard's modified, Duggar's and Harshberger's nutrient solutions.
   (b) with agar—dextrose 2%, dextrose 10%, laevulose 2%, Richard's and Uschinsky's solutions and Harshberger's with 2% dextrose.

Source and methods of isolation.

The species of Fusarium studied in this work were obtained from the roots of wilted aster, garden and sweet pea, and lupine, In addition, for purposes of comparison, three cultures were obtained from outside sources. The source of the different organisms in isdicated in the table following:

D—Sweet pea roots.
F—Aster stem (just below surface of soil).
G—Garden pea stem (obtained from Maine).
H—Aster stem (obtained from Maine).
J—Bean roots (obtained from Cornell).
K—Lupine roots.
L—Lupine roots.
N—Lupine roots.

G is a culture of *F. orthoceras* A & W., and H is *F. conglutinans* Woll., both originally isolated by Lewis (7: 1913) and obtained through the courtesy of Dr. W. J. Morse, of Maine University. J is culture of *F. martii phaseoli* Burk., originally isolated by Burkholder (2: 1919) and secured from Cornell University. F was isolated from a wilted aster in a garden in Notre-Dame de Grace, Montreal. The remaining organisms were secured in the vicinity of Ste. Anne de Bellevue, Que.

In the isolation work every effort was made to secure absolutely pure cultures. The roots of the wilted plants were washed and placed in moist chambers. A superficial growth of mycelium appeared over the surfaces. Transfers were made from different parts of the root systems (in case a number of species might be present) to tubes of agar. When there appeared to be more than one organism present the cultures thus obtained were carried for several weeks and transfers made.

In order to secure absolutely pure cultures, final isolations were made from each culture by means of the poured plate method. The transfers were made from single colonies when they appeared visible on the surface of the agar under a pocket lens (20 x). In most cases the cultures thus obtained were found to

be identical with the original cultures. In one instance, however, two different types of colonies appeared on the poured plates. Separate transfers were made and organisms K and L were made.

By means of this method seventeen pure cultures were obtained. As the experimental work progressed it became evident that a number of them were duplicates. These were accordingly discarded and the work completed with five isolations secured in the manner described and the additional three obtained from Maine and Cornell.

During the course of the investigations, stock cultures of the eight organisms were maintained, transfers being made approximately every three weeks. From these stock cultures subcultures were made on the various media used in the different experiments. Frequent microscopic examinations of these stock cultures were made as check on their purity. In no cases were any contaminations detected.

Classificaton of the organism studied.

The genus, in order to facilitate its study, has been divided into a number of sections by Wollenweber (16: 1913) and by Sherbakoff (12: 1915). The writer has grouped the organisms here studied according to these sections.

Section Elegans.

1. *F. orthoceras* A. & W. Wollenweber (16: 1923) gives the following diagnosis of this species: sporodochia and a reduced pionnotes present, inmasses salmon coloured, the conidia of both being 3-septate, up to 100%, 25-45 x 3.25-4.5 u, 4-septate, up to 25%, 5-septate up to 10%, where they are 40-50 x 3.75-4.75 u in size; sclerotia blue on steamed potatoes; slight lilac odour on steamed rice; common soil organism and a vascular parasite on many hosts, as, Solanum, Vigna, Pisum, Ipomoea, etc.

No. G in the series here studied agrees closely with this description. The lilac odour is not pronounced, however, and the colour is more of a cream shade than salmon. The 3-septate spores are 21.0-45.5 x 2.6-4.4 u, 4-septate, 35.0-42.0 x 3.5-5. 2 u. Only a single 5-septate spore was observed and it measured 45.5 x 4.4 u.

2. No. F differs in some respects but as a whole coincides fairly closely. It is a more vigorous organism in amount and rate of growth and spore production than G, but when colour is produced in the medium (wine-red on rice) the latter organism gives a more intensive hue. The 3-septate spores measure 22.5-52.5 x 2.6-6.1 u, 4-septate, 35.0-49.0 x 3.5-6.1 u, 5-septate, 38.5-52.5 x

4.4-6.1 u. While these measurements fall fairly well within the limits given for G, the 3- and 4-septate types average higher, as the following table shows :

	3—septate	4—septate
No. F	35.6 x 4.3 u	43.6 x 4.6 u
No. G	32.7 x 3.6 u	36.2 x 4.6 u

No. G produced typical conidia of the Elegans type on bean, Uschinsky's and Richard's agars, and on potato plugs, while in 3. *F. conglutinans* Woll.—Wollenweber (16: 1913). This species differs from *F orthoceras* in the absence of a wine red colour on rice, No. H has all the typical characters of this species, namely, 3-septate spores measuring, 24.5-42.0 x 2.6-4.4 u, averaging 32.7 x 3.9 u, 4-septate forms, (observed only on bean agar), averaging 50.0 x 4.4 u. The production of aerial mycelium is very scanty and, generally speaking, the organism appears to be lacking in vigour probable by reason of the length of time it has been carried in culture.

Section Gibbosum.

4. *F. gibbosum* A. & W.—Appel and Wollenweber (1 1910), Sherbakoff (31: 1915). Diagnosis-conidia often with hyperbolic dorsal curve, breaderin middle, long narrow apex, pedicellate, typically 5-septate, 40.0-46.0 x 4. 4-4.7 u, (averaging 41.6 x 4. 6 u), also 0- to 7-septate, in minute sporodochia or spreadin over the mycelium singly, hyaline to light pinkish cinnamon; chlamydospores intercalary: short fine ærial mycelium present; zonation; substratum onpotato agar pale flesh to cinnamon.

No. K. differs from this in the following respects:—conidia typically 3-to 5-septate, the fomer measuring 17.5-38.5 x 3.5-6.1 u, (averaging 28.1 x 4.4. u), and the latter, 28.0-57.5 x 3.5-6.1 u, (averaging 43.3 x 4.8 u); colour on potato agar golden brown. In other characters No. K is practically identical with *F. gibbosum* and it may possibly be variety occurring on Lupinus.

5. *F. Lanceolatum* Pratt—Pratt (10: 1918) gives the following diagnosis of this species;—conidia typically in pseudopionnotes, also in aerial mycelium and sporodocdhia, from nearly straight to strongly curve, pedicellate, typi--cally 3—to 5-septate, rarely higher, 3-septate measuring 22,0—52.0 x 2.5—5.0 u, (34.0 x 3.5 u), 4 septate, 22.0—60.0 x 2.8—5.0 u, (40.0 x 4. 8 u), 5 septate, 36.0—70.0 x 2.8—5.7 u, (48.0 x 4.1 u); scanty aerial mycelium, sporodochia and pseudopionnotes ochraceous orange at first, later becoming reddish; substratum on rice yellow to dark brown; chlamydospores single and in chains; isolated from the soil.

No N differs from this in certain points:—the conidial measurements are : 3 septate, 21.0—45.0 x 2.6—6.1 u, (31.6 x 4.3 u), 4 septate, 28.0—49.0 x 2.6—6.1

u, (37.3 x 4.6 u), and 5 septate, 31.5—52.5 x 3.5—6.1 u, (40.1 x 4.6 u). The production of deep shades of red by the conidial structures has not been observed, but salmon pink and orange are produced on several media. While it scarcely can be said to be scanty the production of aerial mycelium is far from plentiful. Of the various species described in this section, *F. lanceolatum* appears to agree more closely with No. N than any other. The question again arises as to whether or not these differences noted above are of specific or even varietal importance, but further study will be necessary before a decision can be reached in this regard.

Section Martiella.

6. *F. martii phaseoli* Burk.—Burkholder (2: 1919). Macroconidia mostly 3-septate, (44.5 x 5.1 u), 4 septate (50.09 x 5.3 u), rarely 5 septate, of nearly even diameter throughout, more or less curved near the apex apedcellate. Microconidia rare. Aerial mycelium scanty and white. Spore in pseudopionnotes. Chlamydospores terminal or intercalary, single or in short chains. Shades of green ,blue and purple in culture. Causes dry rot of roots of *Phaseolus vulgaris* and other Phaseolus spp.

No. J. agrees with this description in every respect, except that the spores appear to be slightly smaller, 3 septate, 24.5—52.0 x 2.6—7.0 u (40.5 x 4.9 u) and 4 septate, 40.2—56.0 x 4.4—6. 1u (49.5 x-5.5 u). The character for colour production is not strongly are quite faint.

7. *F. solani* (Mart.) Sacc.)—Appel and Wollenweber (1: 1910) and Sherbakoff (12: 1915). Microconidia always present on aerial mycelium. Macroconidia somewhat broader in upper half of lenght, rounded to slightly constricted apex, non or slightly pedicellate, typically 3 septate, 27.0—34.7 x 5.4—5.8 u (29.75 x 5.5 u), also 4 and 5 septate. Aerial mycelium poorly developped, white to olive buff. Substratum on potato agar oli ve buff with green blue tinge. On tubers of *Solanum tuberosum.*

No. L of this series closely with this description. It is an outstanding organism especially in the number of spores produced, masses of spores being developped on practicelly every meduim used. In some cases the entire surface of the culture is made powdery by the presence of tremendous numbers of spores. They are very uniform in shape and size, measuring, 3 septate, 24.5—42.0 x 3.5—7.0 u (31.6 x 5.6 u), 4 septate, 31.5—44.0 x 5.2—7.0 u (36.2 x 6.2).

8. *F. lathyri* Taub.—Taubenhaus (14: 1914). Macroconidia sickle shaped slightly curved, 3 to 4 septate, mostly 3 septate, latter measuring 15.8—30.8 x 4.2—5.6 u. Microconidia elliptical to oval. Chlamydosphores spherical, thickwalled, spinulate when old, borne singly or in short chains. Causes wilt and root-rot of *Lathyrus odoratus.*

No. D appears to be the same organism. It was isolated from the roots of wilted sweet peas, and, all the writer was unable to secure infection with it, it agrees very closely with the description given by Taubenhaus for *F. lathyri*. The macroconidia are typical in shape, from 2– to 5–septate, mostly 3–septate, which measure 17.5—35.0 x 2.6—6.1 u (29.5—4.2 u) The chlamydospores are comparatively small, round, and occur singly, in short chains, and in small clumps.

Growth on various media.

In the limited time available it will be impossible to give the detailed results of the various experiments carried out under this hand. A brief discussion of these results will be all that is possible.

a. Effect of the medium on growth characters.

There is a wide variation in the type of growth from an entire lack of aerial mycelium with a tough leathery surface layer, as *F. Orthoceras* on iris leaf juice agar, to dense aerial growth, as *F. solani* on Richard's solution. All gradations between these extremes may be found and the different organism have various abilities in this regard. The vigour of the organism is possibly involved, a vigourous one producing aerial growth on more media.

Colour varies widely within each species. It may be present on one medium and absent on another. The intensity also varies. However, there seems to be a typical fundamental colour for each organism which will be produced to some degree when any colour is present. The vinaceous colour of *F. orthoceras* is an example of this. Harshberger's nutrient solution agar with 2% dextrose is the best medium for colour production.

The character of the mycelium varies greatly but not constantly, and consequently this charactere is suseless from the taxonomix standpoint. There are variations in the width of the hyphea, cell length, and protoplasmic content.

The production of chlamydospores is usual on certain types of media and seems to be associated with a lack of proper nutrition. The sugar agars and Harshberger's solution agar are examples of this type of medium. There is a variation in the size, number and contents of these structures.

The conidia from one of the most variable characters. Microconidia and macroconidia appear on the different media in varying proportions. An abundance of conidia is seldom found when large numbers of chlamydospores are present. The size of the macroconidia and their septation appear to vary about a more or less constant, mean, and consequently the more measurements that are taken the more nearly will this mean be approached . The great variation in the percentages of the different types of septation also makes the observation

of large numbers advisable if the results are to be of any value for comparative purposes.

b. Effect of temperature.

Within the limits studied (20°c—28°c) certain facts are quite clear in regard to the effect of temperature. The amount of aerial browth dependas on the temperature but not constantly for all species, in some cases more being produced at higher than lower and vice versa, as, for example, *F. gibbosum,* which produces more growth at 25°c that at 20°c on Uschinsky's solution, while *F.* Orthoceras produces more at 20°c. Larger spores may be produced at higher temperatures. A more intensified colour is quite characteristic of the growth at higher temperatures. More fungus material (dry weight) is produced at 25°c than at 20°c.

Growth at different concentrations of the H-ions in the media.

In order to secure data on this factor a series of cultures were grown on media (Duggar's and Harshberger s'solutions) standardized to different Ph values. Clarke's colorimetric method was used.

The experiments brought a number of interesting facts to light. In the first place it is apparent that the effect of the H–ion concentration depends both upon the medium and the organism. *F. orthoceras* (F and G) shows no differences in growth characteristics on either Harshberger's or Duggar's solutions. The other three species used in this phase of the work, namely, *F. martii phaseoli, F. lathyri,* and *F. gibbosum,* show differences but not constant ones, as is shown by the least mentioned organism, which, at the higher Ph values on Harshberger's produces large numbers of macroconidia ,while on Duggar's ,at similar values it fails to produce any. This supports the results obtained by Webb (15:1919), and Zeller, Sehmitz and Duggar (17:1919).

The second interesting fact is in regard to colour production. Within the limits studied colour production does not appear to be related to the H—ion concentration, but to depend mooe upon the composition of the medium. F. orthoceras (F and G) and *F, martii phaseoli* (J) produce a uniform colour on each medium throughout the whole range of Ph values, but a different intensity on each medium in each case. In the case of *F. lathyri* (D) and F. gidbbosum (K) there seems to be a gradation in the intensity of the colour and the amount present. It must be remembered, however, that there is a similar gradation in the amount of growth exposed to free air in these cultures. Whether this gradation is due to the increasing Ph values or not is a question. The character is so variable that a definite conclusion is impossible. It appears, however, that the colour intensity depends on the amount of free air present rather than on the

PH value of the medium. Burkholder (2: 1919) makes a similar statement in connection with his study of *F. martii phaseoli.*

Generally, speaking, therefore, the concentration of the H-ions in the medium does not appear to be the only limiting factor for growth characteristics, but is of importance when taken in conjunction with other factors, such as temperature, and the composition of the medium.

Summary.

1. *F. lathyri* Taub. has been isolated from the roots of wilted sweet peas *F. gibbosum* A. & W., *F. lanceolatum* Pratt. and *F. solani* (Mart) Sacc, from wilted upines, and *F. orthoceras* A. & W., from wilted asters.

2. These species, and in addition, *F. martii phaseoli* Burk. *F. conglutinans* Woll. and another strain of *F. orthoceras* A. & W., have been studied in culture, to determine the effect of various media. The temperature, and the H-ion concentration of the medium on the various growth characters.

3. The type of growth varies on different media from a complete absence (*F. orthoceras* on iris leaf juice agar) to a profuse production of aerial mycelium (*F. solani* on Richard's solution).

4. The colouration varies both in intensity and in the actual colour produced.

5. The production of chlamydospores appears to be related to poor nutrition and is characteristic of such media as Harshberger's solution agar and the different sugar agars.

6. The type and proportion of conidia present and the size of the macroconidia present appear to very about a more or less constant mean.

7. The total amount of fungous growth is greater at 25°c than at 20°c on ischinsky's solution for all the species studied.

8. More intense colours are usually produced at the higher temperature.

9. The spore size is only slightly and not constantly influenced by the temperature.

10. The production of aerial growth is usually greater at 25°c that an 20°c but again this is not constant, differing both with the organism and with the medium.

11. Some organisms show a gradation of growth characters with varying H-ion concentration on the same medium, e.g., *F. lathyri, F. martii phaseoli* and *F. gibbosum.* On the other hand, *F. orthoceras* (both strains) does not show this gradation . It appears, therefore, that the H-ion concentration of the medium is not the only factor affecting growth characteristics.

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White Birch on the Driveway, Ottawa, partially destroyed by Borer (*Agrilus anxius*).

White Birch at Ottawa destroyed by Borer (*Agrilus anxius*).

Eggs of Bronze Birch Borer (*Agrilus anxius*) x 9 diam.

SOME BIOLOGIC OBSERVATIONS ON THE BRONZE BIRCH BORER AGRILUS ANXIUS GORY.

By C. B. Hutchings, Assistant Entomologist, Division of Forest Insects, Department of Agriculture, Ottawa, Canada.

The Bronze Birch Borer is one of the worst enemies of the Birch. Extensive observations made by the Division of Forest Insects of the Entomological Branch, at Ottawa, in different parts of Ontario and Quebec point to the widely spread ravages of this pest in Canada. It has also been reported as operating seriously in many of the Eastern and Middle States of America. Not only are the cultivated birches—those grown under more restricted conditions in private gardens and parks—subjected to severe attack, but those found in the forest wilds in their natural habit alike fall a ready prey to the *Agrilus* beetle. In and around Ottawa the various species of this shade tree have been infested for many years. The cut-leaf varieties have suffered the most, although no species appears to have been entirely immune. At the Central Experimental Farm, in the Driveway, and in many of the city gardens handsome large birches are being gradually killed off in this way. During some seasons the attacks are of less severity. This may be due to various agencies, such as weather conditions, health of host, parasites and birds. It has been found that a cold deferred spring will keep back the development of the larvæ and delay the adults coming to the exterior, while a wet summer will tend to increase the vigour of the tree so that its powers of resistance to withstand insect attack are increased.

The damage is all done in the larval stage and is of such an insidious character that often the presence of the insect cannot be detected until it has become well established within the host. When once a tree is attacked, its fate is sooner or later, a foregone conclusion. One of the first signs of the presence of the borer is the drooping of the topmost branches as if these had been wilted by fire or girdled. Gradually they die off and present a stag-head appearance, while the rest of the tree appears to be healthy, green and vigorous. The attack having begun in the head of the tree, continues on downwards, branch after branch, wilting and dying off in turn as the larvæ eat their way into the fresh, succulent bark until the entire trunk and all the under branches have been completely covered by a net work of very intricate tunnellings.

Unlike many of the important wood borers, such as *Cyllene robiniae* on locust, *Goes pulcher* on hickory, *Monochamus marmorator* on balsam, *Prionoxystus macmurtrei* on red oak, all of which indicate their presence by the piles of sawdust found ejected at their tunnels' entrance, *Agrilus anxius* exhibits no such index of its presence and except for a very little frass pushed out early in its career

packs the tunnel tightly behind it with borings as it goes forward. However, the larvæ show other signs quite distinctive,and one of these is a certain wavy character of the bark. The outer surfaces of the branches and trunk may often be raised in small undulations due to the operations of the grubs as they tunnel just below in the outer bark. Another good sign is the presence of dirty, reddish-looking patches on the white bark surfaces, often with rusty-coloured sap trickling from them. These spots are quite small at first but later may reach a size of several square inches, presenting very unsightly markings which greatly detract from the beauty of the tree.

The adult belongs to that destructive group of wood-boring insects, the Buprestids which are commonly known as metallic beetles. It is slim in outline, olive-bronze in colour and about 10mm long. The sexes are quite similar in appearance except that the male has a slight depression on the first abdominal segment. The beetles are very active specially during the bright warmer parts of the day. They fly rapidly from branch to branch and chase one another up and down the bark with great alacrity. They have a habit of raising the wing covers as if about to fly and of stretching and exposing themselves to the direct sunlight where they will lie basking for long intervals at a time. If approached, even very cautiously, they at once display signs of uneasiness; and if in the slightest way disturbed will fly away quickly , disappearing as by magic. At other times they will dodge the observer from side to side of the trunk in order to elude him. If approached near enough to be touched, they almost invariably feign death and drop to the earth; although occasionally they hold tenaciously to the bark surfaces and will not give up except forced to do so.

Under close conditions in the laboratory, mating was commonly observed. This occurred early in June and egg laying began immediately afterwards. Fresh birch sticks were cut and placed in the cages for the beetles to oviposit on. The females would examine the surface of these with great interest, feeling the bark with their short serrate antennæ, running rapidly from one depression to another, probeing these with their long ovipositors as they sought suitable locations to deposit their eggs.

Oviposition was carried on during the warmer parts of the day, the bright sunshine being a marked simulant for activities.

It was the writer's good fortune to discover the eggs of *Agrilus anxius* during summer of 1920, after several seasons study on this problem. The original description is now given here for the first time. The egg is oval in outline, much flattened on two sides, length1.25 to 1.50 mm.; width.75 to 1 mm.; chorion soft, wrinkled and finely reticulated; pale cream-white when first laid changing to yellowish tints, chiefly at the pole ends. Adheres well to the surface and is coated over with a very thin, semi-transparent white filament. This last is

applied after deposition as a cement to protect the soft shell during incubation. In the accompanying illustration one of these menbranous coatings will be seen detached on the left of the group of eggs. A specially designed cage 12″ x 12″ x 14″ with glass sides was used in connection with this work.

On hatching, the small larva 2 mm. in length, leaves the shell from the underside of the egg and enters the bark at a point immediately below. The minute cuttings and frass are passed back into the shell case from which emergence has recently occurred and tunnelling begins at once. The young legless grub slowly starts to eat its way down to the softer and more sappy areas, leaving behind a very fine almost threadlike way of progress. This line of route may be straight, winding or very tortuous; but usually it is fairly direct at the start. Later on it becomes sinuous and very irregular, and where several larvae are working together, as often happens, the tunnels cross and interlace in such confusion that it is impossible to trace any particular one for any length A closer study of the tunnels reveals certain slight enlargements here and there along the line. These recesses mark the places where the larva has moulted and as may be expected the distance apart of the first moults is small, but the stadium increases gradually as the larva gets bigger. Five moults are required to bring the larva to maturity. It is then a flat, legless grub, dull white and about 22 to 25mm. long. The last resting point is important. The larva constructs in the woody area near the outer surface, a boat-shaped cell in which it transforms. The beetle afterwards cuts its way to the exterior and emerges through a lunar shaped or D-shaped hole on the bark, a characteristic which is common to this genus, completing its lifecycle in one yard.

Some observations were made in feeding and it was found that the beetles partook sparingly of birch foliage. An effort was made to determine what degree of preference was shown for various shade trees, and it was noticed that a marked liking was exhibited for poplar, the leaves being freely eaten, specially the young ones; while willow was next in choice and birch came last and was scarcely touched. Elm they would not eat, nor any of the conifers. These beetles are edge feeders, that is, they nibble small pieces from the leaf margins, cutting out semi-circular patches here and there, as they go, seldom, if ever severely attacking any one leaf.

No effective control has as yet been devised for this pest despite considerable work having been done toward this end. Severe pruning will tend to check the spread of the beetles; but this is only a temporary measure and in the end leads to the inevitable destruction of the tree. Where birches are planted in large numbers along driveways, in parks and groves, it is well to take drastic action by cutting out the infested tree and burning trunk and branches early in

the spring before the buds are out. This will prevent the beetles going to the other trees nearby.

Washes for the trunk are unsatisfactory, chiefly because of their staining the bark; and spraying is of no avail. Hymenopterous parasites are undoubtedly the greatest natural controlling agency. Every year considerable numbers of the small chalcid fly, *Phasgonophora sulcata* Westwood, were to be found breeding in the birch sticks. This parasite is of first importance in control of *Agrilus anxius*. There are also several species of Siricidae, horntails, which attack the larva. No doubt birds play an important part in control. The downy woodpecker, chipping sparrow, phoebe, king bird and two species of warblers have been observed at the Arboretum, Central Experimental Farm, among the branches of *Betula ulmifolia* and *B. fruiticosa*, both of which were very heavily infested with *Agrilus*.

To sum up very briefly:—*Agrilus anxius* is perhaps the most serious insect enemy of the birch family. Injury is done in the larval stage, by a series of winding tunnels beneath the bark thus girdling and eventually killing the branches and trunk. No effective artificial control is known, but certain natural agencies, such as parasites and birds play a good part. Infested trees should be cut down and burned in the early spring. It is, therefore, very unsatisfactory to plant birches of any variety for ornamental or shade purposes and we do not recommend the practice.

BLUE STEM OF THE BLACK RASPBERRY.

By J. F. Hockey Laboratory of Plant Pathology, St. Catherines, Ont.

This disease has not been previously reported from the Niagara district Probably few are acquainted with it because of the comparatively little attention paid to black raspberries in this section. The blue stem condition as described by W. H. Lawrence (Wash. Agr. Expt. Sta. Bul. 108, 1912) was found this season in various patches through the district and in isolated seedling plots at the Horticultural Experiment Station, Vineland.

In most cases the entire plant was defoliated or nearly so, in the latter case the remaining leaves were yellowish and drooping. Occasionally a plant was found with one or two canes apparently dead whereas the remaining canes showed the blue colorations developing along the base of the stems with the tips of the canes still normal. The color of the diseased stems is a bluish purple to black

On a macroscopic examination of the diseased canes in the field and laboratory no superficial fungous growth could be observed. This appeared only when the specimens were placed in moist chambers. An examination of free hand sections of the stems revealed the presence of strands of mycelium in the wood elements. Some of the tracheae were completely plugged with mycelium No evidence of internal fruiting bodies have been found in these examinations.

Specimens of diseased canes were placed in moist chambers in order to observe any fungous growth which might take place and especially the predominate growth on cut surfaces of the canes.

Small pieces of the internal tissue were used in making initial cultures on nutrient agar. These cultures yielded a very predominant fungous growth closely resembling that isolated by Lawrence in Washington and described in 1912 as *Acrostalagmus caulophagus*, Lawrence. Typical verticillate conidiophores were produced in abundance, bearing at their tips heads of conidia enclosed in droplets of hygroscopic slime which disappears in solution immediately when placed in water.

The specimens placed in moist chambers yielded the same fungus on the cut surfaces, fruiting abundantly. On the bark too were found minute scattered tufts 0.25—0.5mm. in diameter and height, which on close examination were found to be the conidiophores of this fungus. The heads of conidia varied in diameter from 10-30u with the average from 10-15u. These contained many hyaline spores, oblong to oval in shape and from 3-8ux2-4u in size.

There is still doubt as to the specific name of this fungus. Carpenter (Jour. Agr. Res. 12, 9: 529-546, 1918) is strongly of the opinion that the fungus described by Lawrence as *A. caulophagus* does not differ from *Verticillium albotrum* (R. and B.) sufficiently to warrant the adoption of another name.

In U. S. D. A. Plant Disease Bulletin for Nov. 1, 1922, Dr. C. L. Shear reports the presence of this disease in Michigan, having isolated the fungus from material collected in that state. The presence of blue stem in Ohio and New York State is also reported by R. B. Wilcox and W. H. Rankin respectively. In the same Bulletin an infectious blue stem distinct from that described by Lawrence is reported prevalent at Geneva, N. Y. This condition has not been observed in the Niagara district this year, as all material collected has yielded the same fungus in culture.

SOME RESULTS FROM SPRAYING & DUSTING APPLES IN QUEBEC.

By C. E. Petch, Dominion Entomological Laboratory, Hemmingford, Que.

During the past four years four spraying systems have been tested in the same orchard on the same variety. The variety chosen was Fameuse, because it is very susceptible to apple scab (Venturia pomi) and many of our common insects, especially apple maggot (Rhagoletis pomonella).

The spraying schedules used were as follows:

PLOT NO. 1—NOVA SCOTIA SPRAY CALENDAR

Green Tip Spray —Bordeaux 3-10-40+arsenate of calcium 1 lb
Pink Bud Spray —Bordeaux 2-10-40+arsenate of calcium 1 lb
Calyx spray —Soluble sulphur 1 lbs; hydrated lime 5 lbs; cal. ars. ½ lb
After calyx spray—Bordeaux 2-10-40—arsenate of lime 1 lb.

PLOT NO. 2—ONTARIO SPRAY CALENDAR

Green Tip spray —Lime sulphur 1 gal. to 20 water
Pink Bud spray —Lime sulphur 1—40+arsenate of lead 1½—40
Calyx spray —Lime sulphur 1—40+arsenate of lead 1—40
After calyx spray—Lime sulphur 1—40+arsenate of lead 1 lb—40

PLOT NO. 3

Green tip spray —Lime sulphur 1.008 sp. gr.+calcium arsenate ¾ lb—40
Pink bud spray —Lime sulphur 1.007 sp. gr.+calcium arsenate ¾ lb—40
Calyx spray —Lime sulphur 1.006 sp. gr.+calcium arsenate ¾ lb—40
After calyx spray—Bordeaux 3—10—40 +calcium arsenate 1 lb—40

PLOT NO. 4

Pink bud spray —Lime sulphur 1.010 sp. gr.+calcium arsenate ¾ lb—40
Calyx spray —Lime sulphur 1.009 sp. gr.+calcium arsenate ¾ lb—40
After calyx —Lime sulphur 1.007 sp. gr.+calcium arsenate ¾ lb—40
Spray 2 weeks later—Lime sulphur 1.007 sp. gr.+calcium arsenate ¾ lb—40

As often as possible the applications were made on the same day and there was never over 24 hours between any of them. The average of the injuries for the past four years has been as represented in the following table:—

PLOT	SCAB	INSECT INJURY	RUSSETING	FOLIAGE INJURY
No. 1	1.86%	2.5 %	9.25%	2.5 %
No. 2	1.39%	2.0 %	0.0 %	3.75%
No. 3	.85%	1.63%	1.25%	2.50%
No. 4	1.34%	1.55%	0.0 %	4.25%

The average cost of 100 gallons of the mixtures for the past 4 years has been as follows:

YEAR	PLOT 1	PLOT 2	PLOT 3	PLOT 4
1919	5.00	4.31	4.32	3.93
1920	5.43	5.91	4.44	3.93
1921	3.37	4.85	3.74	3.91
1922	3.24	6.09	3.62	3.35
Average	4.26	4.79	4.03	3.78

During this four year period the injury to the foliage has been slightly more in the lime sulphur plots but this has been far surpassed by the injury to the fruit by the use of Bordeaux mixture. The Bordeaux mixture used was not the ordinary 4—4—40 but one containing a small amount of copper sulphate and an excess of lime. Bordeaux injury was most injurious when wet weather followed the application. Considerable trouble is experienced through clogging nozzles, etc. when using this Bordeaux because of the large amount of lime present. It is usually more costly and not as convenient to use as lime sulphur. This past year the Bordeaux sprayed plot had 6% of scab whereas the lime sulphur plots had less than 4%. This result was due to the use of soluble sulphur in the calyx spray, and to our infestation of scab coming between the calyx and after calyx applications. It would seem the use of soluble sulphur for the calyx spray is the great weakness of the Nova Scotia spray calendar and this point would have been more clearly brought out if there had been a heavy infestation of scab here this past year.

Calcium arsenate has given equal results to lead arsenate in insect control but it has advantages which make it preferable. It is less costly and does not cause any appreciable chemical change when mixed with lime sulphur. In 1921, lead arsenate in combination with lime sulphur injured a large number of apples chiefly at the calyx end. The injury was usually in the form of a circle but in severe cases streaks formed on the sides of the apples. The skin was cracked and turned to a dull brown color. This type of injury did not occur in orchards sprayed with calcium arsenate and lime sulphur.

Dry lime sulphur has been tested the past two years on McIntosh and Fameuse apples with the following results:

1921. Dry lime sulphur 2 lbs—water....40 gals. (3 applications)
Fameuse.....39.9% scab
McIntosh.....3.45% scab
1922. Dry lime sulphur 3 lbs to 40 gals water (3 applications)
Fameuse.....14.0% scab
Dry lime sulphur 4 lbs—40 gals water (3 applications)
Fameuse.....11.1% scab
McIntosh.....20.8% scab

These results show that this material has not given satisfactory control of apple scab on our most important varieties. When used at a strength over 3 lbs to 40 gals. it is more costly than commercial liquid lime sulphur. From my experience it has no advantages in handling. The only place for its use at the present time is with the very small grower, where the quantities used would be trifling.

Dusting continues to give satisfactory results in some orchards and this year in one orchard apple scab was present on only 1% of the Fameuse apples. In this orchard the expensive mixtures were not used but mixtures containing 50% sulphur 45% talc or hydrated lime and 5% insecticide. The use of these diluted mixtures reduced the cost almost 50%. The use of Bordeaux dusts has given bronzing and russetting every year and it has been decided not to recommend their use in this province. Calcium arsenate has been used at rates of 5% to 10% of the mixtures containing no hydrated lime and there has not been any foliage or fruit injury during the past six years. Materials for increasing the adhesion of dusts to foliage and fruit are greatly needed but to my knowledge there are none known at the present time which are satisfactory. Among the many things tried wheat flour was the only one that gave promise of being worth while in orchard dusting. Further experiments with wheat flour at various strengths are to be carried out in 1923.

The above remarks are relative to this province and I would advise those living outside Quebec not to adopt any of the above mixtures in a commercial way unless they have been tested and found satisfactory for their conditions.

RESULTS OF ONION MAGGOT CONTROL WORK, 1922.

By W. J. Tawse, Dept. of Horticulture, Macdonald College.

The onion maggot (*Pegomyia ceparum*, Bouche) control work was again carried on under field conditions both at the College and with co-operating market gardeners around Montreal. The pan system of setting out the poisoned bait was used entirely as the diagonal spray was too costly, both as regards time and material and further under local climatic conditions the results were very uncertain. The dry hot winds at this period of the growing season have completely evaporated other sources of moisture and in consequence the maggot flies or adults are quickly attracted to the pans of poisoned bait.

It is to be regretted that Mr. Sauvé on the Côte des Neiges Road was unable to carry on the experiment after setting out the pans and filling them

once; but due to the expiration of his lease and the possibility that it would not be renewed, he allowed all work to lapse. We hope now that it has been renewed that he will cooperate in 1923.

The materials used including the poison, sodium arsenite and molasses, as well as the pans, were furnished by the growers themselves. They found the work done in 1921 was a distinct profit to them and were very pleased to furnish material and carry out the necessary work according to our directions.

The following tables will give a clear understanding of the work carried on at the College and in Rosemount. It was also thought advisable to append the temperature observations for the month of May and June as some periods in May were very hot and dry, while June was marked by a higher precipitation than usual.

Onion Maggot Control.

Date Sown	Dates of Application	Amount of Material and Labor	Remarks
April 25th-26th.....	May 23rd.....	30 pans. 3¼ gals. 1 hr.....	Excellent germination of seed and very thick stand. First eggs were found May 24th on trap onions. May 26th numerous eggs on trap plants but none on field crop.
	May 27th.....	30 pans. 3½ gals. ½ hr.....	Weather has been hot with thundershower on the 25th. Cooler on the 27th, then warmer again.
	May 31st.....	30 pan . 4 gals. ½ hr.....	Fine and warm. Flies observed sipping poisoned liquid.
	June 5th.....	30 pans. 4 gals. ½ hr.....	Showers and very warm. Crop looks excellent. Pans evaporating quickly.
	June 10th.....	30 pans. 3½ gals. ½ hr.....	Showers after a very dry period and cooler. Adult flies very numerous and first maggot injury found in untreated plots.
	June 14th.....	30 pans. 3½ gals. ½ hr.....	Maggot injury in plots very light Adults very numerous. Increased sodium arsenite to ½ oz. per gal. which seemed to attract and kill the adults much quicker. Counted 50 dead by night in and around one pan.

June 20th, the pans were collected and cleaned ready for next year.

May.

Day of month	Maximum Thermometer	Minimum Thermometer	General state of weather		Remarks	Depth at morning observation. Rain.	Depth at evening observation. Rain.
			Midnight to noon	Noon to Midnight			
1	64.0	36.5	Clear	Clear			
2	69.0	44.0	"	"			
3	63.5	44.5	"	"			
4	64.0	46.5	"	Rain			.34
5	50.0	44.0	Rain	Cloudy		.58	
6	57.5	42.5	Clear	Rain			.20
7	61.0	46.0	Showers	Showers		.03	.08
8	61.5	45.0	Clear	Clear.			
9	69.0	45.5	"	"			
10	74.0	48.0	"	"			
11	65.0	45.5	"	"			
12	63.0	44.0	"	"			
13	68.0	44.5	"	"			
14	70.5	43.0	"	"			
15	71.5	48.0	"	"			
16	71.5	43.0	"	"			
17	69.5	46.0	"	"			
18	70.5	47.0	Clear	Rain	Showers		.20
19	69.5	49.5	Rain	"	"	.08	.19
20	65.0	56.0	"	Clear	"	.05	
21	69.0	57.0	"	"	"	.02	
22	68.5	46.5	Clear	"			
23	70.5	45.5	"	"			
24	77.5	46.0	"	Rain	Showers		.25
25	80.0	46.0	Rain	Clear		.07	
26	72.0	52.0	Clear	"			
27	69.5	42.0	"	"	Very cold north wind		
28	77.5	43.5	"	"			
29	78.0	54.5	"	"			
30	69.0	50.5	"	"	Smoky from		
31	84.0	48.0	"	"	forest fires.		
Sums	2130.0	1440.5				.83	1.26
Means	68.7	46.4					2.09
					Total precipitation		

June.

1	74.5	64.5	Clear	Cloudy.			
2	75.0	47.5	"	"			
3	75.0	57.5	Rain	Rain		.74	.07
4	79.0	59.0	Clear	Clear.			
5	84.0	56.5	"	Rain			.15
6	79.0	63.0	Cloudy	Clear.			
7	84.5	62.5	Clear	"			
8	87.5	66.0	"	"			
9	63.0	58.5	Rain	Cloudy		.28	
10	71.5	55.0	Cloudy	Rain			.13
11	72.5	56.5	Rain	"		.50	.31
12	59.0	56.5	"	Cloudy		.08	
13	64.0	45.5	Clear	Clear.			
14	65.0	47.0	Cloudy	"			
15	73.5	52.5	Clear	"			

June—*Conttnued.*

Day of month	Maximum Thermometer	Minimum Thermometer	General state of weather		Remarks	Depth at morning observation. Rain.	Depth at evening observation. Rain.
			Midnight to noon	Noon to Midnight			
16	74.0	53.5	"	Cloudy.			
17	67.0	53.5	Rain	Rain		.39	.78
18	57.0	53.0	"	"		.10	.02
19	69.0	54.5	Cloudy	Clear.			
20	74.5	54.0	Clear	"			
21	68.0	60.5	Cloudy	Rain			.07
22	61.0	59.5	Rain	"		.59	.95
23	72.0	55.0	"	Clear		.04	
24	85.5	58.0	Clear	"			
25	76.0	68.5	"	"			
26	73.5	52.5	"	"			
27	71.0	60.0	"	Rain			.79
28	76.0	50.5	"	"			.07
29	71.0	61.0	Rain	"		.18	.05
30	79.0	60.0	Clear	Clear.			
Sums	2181.5	1702.0				2.90	3.39
Means	72.7	56.6			Total precipitation.		— 6.29

Onion Maggot Control, 1922.—Mr. J. J. McEvoy, Rosemount, Que.

Date sown	Date of application	Amount of material used per acre	Labor	Remarks
Two acres in front of storages on April 25th 1922.	May 24th	25 pans. 3 gals.	50 min.	Onions were grown here previous years. Seed sown in rows 12" apart. Vilmorin seed which germinated very poorly and left only a thin stand of plants. Trap plants were planted near pans.
	May 27th	25 pans. 3 gals.	25 min.	Windy and drying winds which evaporate pans very quickly.
	May 31st	25 pans. 3½ gals.	25 min.	Many eggs observed on trap plants. Numerous dead flies around and in the pans.
	June 7th	25 pans. 3½ gals.	25 min.	Ninety-six dead flies inside and around one pan not to mention other species and millers.
	June 11th	25 pans. 3½ gals.	30 min.	Cut-worms working around edge of field were quickly stopped with poisoned bait.

Onion Maggot Control, 1922.—Mr. M. McEvoy, Rosemount, Que.

Date sown	Date of application	Amount of material used per acre	Labor	Remarks
4 acres below orchard sown May 1st, 1922.	May 24th....	20 pans. 4 gals....	1 hour..	Onions were sown with two seeders one sowing much thicker than the other, but there was a very even strong stand of plants
	May 27th....	20 pans. 4 gals....	½ hour..	Adult flies were observed on the 20th. Four eggs were found on trap onions on the 23rd. Adults were observed on the pans on the 27th.
	May 31st....	20 pans. 4 gals....	½ hour..	Pans evaporating very quickly.
	June 6th....	20 pans. 5 gals....	½ hour..	Thirty-seven adults found around on pan. All pans gave high counts of dead adults. First wilting onions are now appearing close to heavily infested in area 1921.
	June 11th....	20 pans. 5 gals....	½ hour..	Fifty-seven dead adults found around one pan. Onions are looking splendidly and very few appear to have been damaged by the maggot.

This grower also treated another large block of onions four hundred yards further down his farm and here again excellent control was recorded with the exception of one end of the block, which was aaross the road from a heavily infested block in 1921. Trap onions were not planted beside the bait pens in this block and more plants were infested with the maggots than where the trap onions were used.

The several species of cutworm were more prevalent than for many years and completely wiped out the onion, carrot, beet and part of the turnip crops growing in Mr. Paul Wattiez's garden in Outremont. Where this injury occurred careful allowance was made so as not to confuse it with damage caused by the onion maggot.

One interesting observation on the poisoned bait which was noted by all workers was the advantage of increasing the quantity of sodium arsenite to one-half ounce per gallon. The greater strength killed the flies very quickly and evidently accounted for the difference in the numbers of dead flies around the pans. Repeated observations showed that the stronger solution pans contained or had around them double the number of dead adults and where two pans, one containing the standard solution of ¼ oz. per gallon and the other ½ oz. per gallon, the flies settled two to one on the stronger solution pan. As the cost of sodium arsenite was only 65 cents per pound the increased cost was only very slight per acre, and growers insist that the stronger solution is preferable.

It would appear from the past two seasons' observations that straw or excelsior in the pans offers a better landing for the flies to sip the liquid than small chips of wood which become waterlogged. The question of the amount of time required to fill the pans with liquid was checked up at each field and very little difference was noted in the quantities used by each grower or the time required to fill them.

Growers came in from other districts to see the work and many more tried out the pan system with success. It seems advisable to set the pans earlier on the sandy loam than on the cooler clay soils and growers seemed uncertain as to the exact time to set out the pans due to the weather conditions. The loss in treated plots at the College was 1.5% and .8%, while the untreated plot showed fully 25% injury by the 20th of June.

The untreated field lying between the two different fields treated by Messrs. J. J. and M. McEvoy showed a 40% loss due to maggot as in some patches practically every plant had several maggots in the bulb. One field of Mr. J. J. McEvoy's onions showed losses due to the onion smut (*Urocystis cepulae*) for all it was treated with the formaldehyde drip when sowing, the quantity applied was too small to be effective. This work will be carried out again during seeding in 1923 and six hundred to seven hundred gallons applied per acre.

The planting of trap crop onions in the rows where the pans will later be placed was the outstanding success of the season's work as the old bulbs used produced large soft tops, which were very much larger than the seedlings and attracted the adult flies. These trap plants were later pulled and destroyed and in all cases the larvae were found infesting the stalk. The trap crop not only attracted the flies to the pans, but also carried a large number of the eggs which would have been deposited on the young seedlings.

Many more growers affected with this pest will carry out control measures in 1923, as already two gardeners in Richmond have asked for information and assistance. These men have given up trying to produce this crop due to their heavy annual losses. The work therefore appears to have been profitable and successful and should be extended in 1923.

EXPERIMENTS IN THE CONTROL OF OAT SMUT.

B. T. Dickson, R. Summerby, and J. G. Coulson.

The chief grain crop in the province of Quebec is oats, and consequently the control of oat smuts is of the utmost importance. The ideal method would be to use absolutely clean seed, but since this is not commnoly possible at present, it is necessary to disinfect the available grain by some means. The usual methods of doing this are those involving the use of formaldehyde either in a concentrated form i. e. equal parts of commercial formalin and water sprayed thoroughly (so-called "Dry Method") or by soaking in, or thoroughly sprinkling with, formalin 1 pint in 320 pints of water. The latter method is safe and gives excellent control, but since it requires considerable time, the handling of quantities of water and formalin, and since it causes swelling of the grain, etc. many farmers do not practise disinfection. If therefore a simpler method can be used it may become more popular.

In this connection considerable work has been done in Australia with stinking smut or bunt of wheat. In 1917 Darnell-Smith (Agr. Gaz. New South Wales 28: 185-189, 1917) reported good control by the use of copper carbonate dust and again in 1919 Darnell-Smith and Ross (Agr. Gaz. New South Wales 32: 685-692, 1919) reported good results. The trials were repeated on this continent in California by Mackie and Briggs in 1920 (Science N. S. 52: 540-541, 1920) and again in 1921 (Phytopath. 11: 38-39, 1921). In 1921 Lambert and Bailey (Phytopath. 12: 36, 1922) confirmed the work of previous investigators and further showed the use of copper carbonate dust in controlling oat smuts.

As a result of this and other work not mentioned here it was decided that a project testing the use of copper carbonate among other disinfectants was worth while and the Crop Protection Institute appointed a committee to organize such a project. Among representative American and Canadian Institutions, Macdonald College was asked to co-operate through the first named author of this paper. Land, seed and labour were provided through the courtesy and co-operation of Prof. R. Summerby of the Agronomy Dept. and Mr. J. G. Coulson, M. A., made soil moisture tests and careful percentage counts during the season. All three authors co-operated in the planning and treatment.

Grain used.

Banner and Hull-less No. 709 MC oats of good average quality were used in the tests. The lots of grain were thoroughly shaken with viable spores of loose smut so that each grain carried a heavy spore load. That this is the case

is shown by the check plots of Hull-less, which had an average of 49 per cent of infected heads.

Treatments.

1. Hull-less No. 709 M. C.

(a) Formaldehyde sprinkle. The grain was sprinkled with a solution of formalin 1 pint in 320 pints of water and covered for four hours.

(b) Formaldehyde spray. The grain was sprayed with a solution of formalin 1 pint in 1 pint of water and covered.

(c) Copper carbonate dust. The grain was thoroughly shaken in a closed container, with copper carbonate dust used at the rate of 2 oz. per bushel. Thorough shaking is essential in order to make sure that such grain is well covered with copper carbonate dust.

(d) Dehydrated copper sulphate and lime dust. The treatment was similar to that in (c) and the dust used at the same rate.

(e) Copper sulphate dip. Grain was soaked ten minutes in a solution of 1 lb. copper sulphate crystals and 1 lb. of common salt in 5 gallons of water, and then for ten minutes in milk of lime (1 lb. of quicklime slaked and made up to 10 gallons by adding water).

2. Banner Oats.

Treatment with copper carbonate dust was the only one used with Banner Oats.

Germination tests.—Germination tests were made immediately after treatment, with percentages on the ninth day as below.

Variety	Treatment	Percentage of germination
Banner Dery	Check	94
Banner Dery	Copper Carbonate, dust	91
Hull-less No. 709 MC	Dehydrated Copper Sulphate and lime	89
" "	Copper Sulphate dip	83
" "	Formaldehyde sprinkle	65
" "	Formaldehyde spray	23
" "	Copper Carbonate dust	90
" "	Check	80
" "	Check	84

Date, etc.—The grain was treated on May 12th and sown on May 16th. At seeding soil samples were taken from various places in the plots and moisture contents measured. The results are given in the below table.

Plot number	0	1	2	3	4	5	6	7	8
Moisture percentage.....	20.75	20.80	19.0	19.90	19.50	19.83	19.50	19.67	19.70

These percentages vary little and are such as give excellent spore germination.

The weather was fine and warm and continued so till harvest, except for a rather rainy week in July.

The seedlings emerged on May 24th, headed from July 17 to 19th, and ripened on August 11 for Hull-less and August for 16th for Banner.

Smut Counts.

Careful counts of smutted heads were made on August 4 with results as shown in the following table.

Plot	Treatment	Variety	No. of smutted heads	Percentage of smut
0.....	Check.....	Banner.....	151	1.5
1.....	Copper carb. dust.	Banner.....	12	0
2.....	Check.....	Hull-less.....	.....	59.0
3.....	Copper sulph. dip.....	"	9	0
4.....	Formaldehyde sprinkle.....	"	110	1
5.....	Formaldehyde spray.....	"	36	0.3
6.....	Copper carb. dust.....	"	41	0.3
7.....	Copper sulph. lime dust.....	"	27	0.25
8.....	Check.....	"	.....	39.3

In plots No. 0, 1, 4, 5, 6, 7, and 8 the number of smutted heads was counted carefully by two individuals on August 4th.

Size of Plots and Replications.

Owing to the act that plans had already been laid for the season's work, it was impossible to obtain the use of much land. Hence the plots could not be replicated. They were one-hundredth acre each in extent.

Consideration of Results.

As was to be expected the germination of Hull-less oats was materially reduced by the formaldehyde treatments. It appears, however, that the copper carbonate and copper sulphate—lime treatments stimulated germination. This statement is made advisedly since more tests should be carried out to determine actually if there is stimulation.

In the control of smut both copper sulphate—lime dust and copper carbonate dust were as effective as the formaldehyde spray within the limits of the experiment.

A STUDY OF SOFT ROT OF IRIS.

By J. K. Richardson, B.S.A., M.Sc.

Introduction.

An important horticultural crop is the Iris of which some two hundred and fifty varieties have been grown at Macdonald College. Of these, approximately one hundred and twenty varieties have died out as a result of disease during the last five years. So far as the writer can ascertain, this loss has been mainly due to "Soft rot" of the plants. Such a soft rot has been described in Europe by Van Hall (10) and a rhizome rot is mentioned by Howitt (5) in Canada. It is the aim of the writer to show by this investigation the cause of Iris soft rot in Quebec, to study the pathological histology and, if possible, to compare the causal organism with that described by Van Hall.

Hosts.

Bacterial soft rots are prevalent in all parts of the country, and the disease occurs on a wide variety of hosts. Erwin F. Smith (9) reports the disease of cabbage, cauliflower, turnip, parsley, celery, lettuce, callalily, radish, cucumber, musk-melon, potato, tomato, pepper, eggplant, hyacinth, onion, rutabaga, and salsify. He also states that in all these cases, with the exception of the last two, rutabaga and salsify, *Bacillus Carotovorus* has been isolated in pure culture.

Howitt (5) gives a similar list of soft rots caused by *Bacillus Carotovorus* but he adds that it also causes a soft rot of the German Iris. It is possible that other authors have mentioned this disease, but the writer has not been able to find other citations.

History and geographical distribution.

The knowledge of the history and geographical distribution of this disease is comparatively vague. The first report of the Bacterial Rhizome Rot of Iris is that of Van Hall, who found specimens of the disease at Sassenheim, in Holland, in the year 1901. He investigated it and described it rather fully in his publication of 1903 (10). During the years directly following this discovery, the disease was found in various parts of the United States by both E. F. smith and L. R. Jones. They, however, did not investigate the disease, since at the time they were working on the soft rots of vegetables, principally the cabbage and the carrot. The organism causing these rots was isolated by them and described as *Bacillus Carotovorus*. The present writer has been unable to obtain any literature in which either of these workers made special studies of the soft rot of the Iris, but Smith (9) states that the disease is caused by the same (or a similar) organism as the one causing the soft rot of cabbage, namely, *Bacillus Carotovorus*

The writer has found that the disease is present at, and in the vicinity of, Macdonald College, the city of Montreal, and around London and Toronto in Ontario.

Investigations tend to show that the soft rot of the Iris rhizomes resembles very closely the rot of the cabbage, turnip, and other vegetables, not only in the effect on the host, but also in the nature of the causal organism. Since the bacterial soft rot of vegetables has been reported from practically all places where the host plants are cultivated, and since the climatic conditions which favour the growth of these vegetables are also very similar to, and sometimes identical with those in which the Iris thrives, it is not at all improbable that wherever soft rot of vegetables is found the bacterial soft rot of the Iris will also occur.

Eonomic importance.

Members of the genus Iris are important commercial plants used for both outside decorative purposes and also in the cut flower industry, but the first mentioned purpose is the more important. There are two types of Iris, the one with and the other without a rootstock or rhizome. The type having the rhizome, although it is of less commercial value than the latter type, is by far the more popular on account of the extreme ease with which it can be cultivated .

The rhizome type of Iris is not an important host for fungus parasites, and the growers lay very little stress on the damage they cause. The bacterial rhizome rot, however, has been becoming more serious in recent years.

As has been already stated, in the year 1901 and 1902 the disease was extremely bad among the Iris plantations in Holland and caused extremely heavy losses to the growers especially in the vicinity of Sassenhem. This is the only report of the disease having occurred in Europe. A thorough search through the literature has given the writer very little information on the economic importance of the disease in this country. It is nevertheless present, because, in various publications, such as E. F. Smith (9) and J. E. Howitt (5), it has been mentioned that there is a bacterial disease which causes the rotting of the Iris rhizomes.

The writer's investigations have shown this disease to be of considerable economic importance to growers, both in Quebec and Ontario. A few years ago, Mr. T. G. Bunting, Professor of Horticulture at Macdonald College, obtained a large number of different varieties of Iris, to be used for decorative purposes around the College campus. The original collection of two hundred and fifty different varieties has been reduced to eighty by the ravages of this bacterial disease during the past five years. Large numbers of infected plants have also been found in the immediate vicinity of Montreal. Often they were completely destroyed by the disease, thus rendering them useless for decorative purposes and a menace to the surrounding plants which are susceptible to the same pathogen.

In the summer of 1921, the writer, on corresponding with Professor Howitt of the Ontario Agricultural College at Guelph, was able to obtain the names of two men, namely C. E. German, of London, Ontario, and C. R. C. Clarkson, of Toronto, Ont., who had been seeking information from him regarding the rot in question. Communication with these two men brought to light the fact that in their respective districts the soft rot of Iris was causing considerable loss to many growers, owing to the destruction of valuable specimens.

In the light of the above facts, there can be very little dobt that the bacterial soft rot of Iris is a disease of considerable economic importance. It is true that the districts from which it has been reported are not extremely numerous but that is no proof that the disease is not widespread. The reason why so little stress has beeen laid on the disease is because those who grow Iris plants in large numbers are not very numerous, and when small growers lose and occasional specimen comparatively little attention is paid to the matter.

Symptoms of the disease.

As far as the writer has been able to observe, the infection and rotting of parts of the plants make take place at any time during the growing season whenever conditions are favourable for the growth of the parasite. Specimens of newly infected shoots were collected from early spring until as late as October 9th.

The disease is first noticeable in the field by the presence of leaves with wilted tips. A closer examination of the shoots shows that they are slightly dwarfed as compared with the healthy parts of the plant. Conditions made it impossible to obtain an illustration of this fact from plants growing in the field. The writer, however, transplanted both diseased and healthy shoots from the same plants, and after placing them in the greenhouse under the same conditions, watched their development. After five months the diseased plant was extremely dwarfed while the healthy specimen appeared quite normal.

After the tips of the leaves die back, the basal portions commence to show watersoaked areas. This watersoaking, which is due to the breaking down of the cells, progresses up the leaf until the latter becomes limp and collapses. The disease spreads from the centre of first infected shoot, upwards, until finally, after a period of from 7 to 10 days from when the first symptoms are noticed, the entire shoot becomes wilted. After the leaves have collapsed, there is often a bacterialooze of a dirty cream colour, which exudes from the base of the shoot just above the ground. Once the shoot has become wilted, it is only a short time till it becomes dried, turns brown, and entirely shrivels up.

In the greenhouse, when plants are kept under bell jars and then artificially inoculated, the symptoms are slightly different, due to the fact that the rotting takes place much more rapidly. In one case an artificially inoculated plant which was growing in sterile sand became entirely wilted for days after inoculation. In a case such as this, there is no apparent dwarfing or wilting of the leaf tips, otherwise the appearance of the disease is similar to that in the field.

In the rhizome the first visible sign is a slight darkened area around the point of infection. This gradually increases until the entire young part of the rhizome has become infected. An examination of the infected part will show the rhizome tissues to be soft and of a thick slimy consistency, as compared with the firm turgid condition of the normal tissue. In a short time the whole infected part will be reduced to a soft, slimy, dirty-gray mass, swarming with the bacteria and emitting a stong unpleasant odour. As the disease progresses in the rhizome, this soft rotten mass gradually loses its moist consistency, be-

coming dry and having a somewhat granular appearance. Althogh the entire central part of the rhizome is totally disintegrated, the tough epidermis remains comparatively unchanged.

The most advanced stages of the disease are characterized by a dead shoot, at the base of which is found a badly affected rhizome. The younger parts are reduced to a dark brown granular mass, with a musty odour, which can be easily separated from the remainder of the rhizome.

Observations show that the infection is rather local in the plant, and not transmitted from one part to another through the rhizome. Unless the weather is extremely favourable, only infected shoots succumb to the disease, the remainder of the plant remaining unaffected. It is the opinion of the writer that the disease is transmitted from one shoot to another through the intervening soil. This was proved by the examination of plants with diseased and healthy shoots, which showed that the only infection that occurred to the healthy shoots was an occasional wilting of their outer leaves, indicating that the pathogen travelled through the soil and not through the rhizome.

Etiology.

Isolation of Organisms.

The writer obtained in pure culture thirty-two organisms from soft rot lesions of different plants. Of these twenty were from Iris, six from turnip, four from cabbage, and two from onion.

In addition, pure cultures of *Bacillus carotovorus* from Wisconsin and Ontario Agricultural Colleges, were placed at the writer's disposal.

The standard technique was used in the isolation of the pathogens from diseased tissues. Young newly infected parts were thoroughly disinfected, then small particles of the inner tissue removed to sterile water blanks from which plates were poured. After the incubation of these plates, cultures were made from individual colonies. In no case were there more than two different types of colonies on the same plate. In cases where there were more than one, each was isolated separately and labelled with an additional a, or b, after the original culture number.

The medium used in all cases was a 2% Iris leaf infusion agar made up according to the following formula:—

Iris leaf infusion	500 c.c.
Dextrose	20 gms.
Agar	20 gms.
Distilled water	500 c.c.

Field Inoculations.

On August 8th, 1921, some twenty-five pure cultures were transferred to agar slants and incubated at 7°C for twenty-four hours. The cultures were then taken to Montreal where they were used for the artificial inoculation of some wild Iris plants which had been located at the edge of a swamp in the outskirts of the city. The inoculations were made by needle pricks in the base of the stem just below the surface of the ground. These operations were carried out late in the afternoon, so as to give the organisms the best possible chance of becoming established before they became affected by the intense heat of the sun during the day. The inoculated plants were carefully observed every day for two weeks and twice during the third week. At the end of this period, no visit ble infections were observed.

On August 16th., day-old cultures were obtained from the twenty-five organisms mentioned above, and inoculated in the same manner as above into cultivated Iris plans on the College campus. These inoculations were observed to regular intervals of two days for three consecutive weeks. At the end of this period, nothing but negative results were obtained.

The writer is unable to explain the reason for these negative results, but it was probably due to the dry environmental conditions which prevailed at the time of inoculation. Although the wild plants were located in a damp field, the entire three weeks during which the observations were taken were extremely dry, there being only one slight shower during the period. Similar conditions also existed after the cultivated plants had been inoculated. Although the inoculations were made late in the afternoon to give the organisms the bes-possible conditions to produce infection, it is not at all unlikely that the dry heat of the ensuing days inhibited their pathogenic action and finally killed them entirely.

Tansplanting.

Before the ground was frozen in the fall of 1921, some four dozen plants were removed from the field and planted into five inch pots with good green-house soil. Half of these plants were placed in cold storage and the remainder were placed in the greenhouse where the temperature ranged from 65°-70°F These latter plants were given a month in which to become established before inoculations were made.

Petri Plate Cultures.

To test the pathogenicity of the isolated organisms before trying to infect the Iris plants in the greenhouse, inoculations with all the organisms were made on slices of raw yellow carrot and also slices of Iris rhizomes. The medium to be used was cut into slices about ¼ inch thick and washed thoroughly in distilled

water, then in mercury bichloride 1: 1000, and afterwards rinsed twice in sterile water to remove all traces of the mercuric chloride. These slices were then placed in sterile petri plates ready for inoculation. In the bottom of each plate there was placed a piece of sterile filter paper, which was kept moist with sterile water while the cultures were under observation.

Carrot inoculations.

The carrot plugs were inoculated on October 28th from agar slope culture thirty-six hours old. The inoculum was placed on the surface of the plug which was then gently pricked with a sharp sterile needle to give the bacteria access to the normal tissues, in case some of the exterior cells had been killed by the mercuric chloride. After inoculation the plugs were incubated at 27oC.

At the end of the third day the cultures were examined with the following results;—1a and 3a showed considerable bacterial growth on the surface of the plug, 4, 7a and 10 showed slight growth, 26b showed considerable growth and apparently slight rotting, and 19b showed growth over the entire surface of the plug and also in the liquid in the bottom of the petri plate, but there was practically no appearance of rot. The remaining slices showed absolutely no signs of infection whatever and could not be distinguished from the check cultures.

After five days the results were slightly more pronounced. In all cases the infections described above were somewhat increased and in addition 15 showed slight bacterial growth on the surface of the plug.

In all cases where infection had been obtained, isolations were made to agar slants and labelled with the letter "C" after the organism that had caused the rot. Thus, for example, the organism which had been isolated from the rot caused by "4" was labelled "4C" and so on with all cases.

Iris Plug Inoculatons.

On November 16th, slices of Iris rhizomes were inoculated in a similar manner with forty-eight hour old cultures of all the original organisms and also the organisms that had been isolated from the infected carrots. These were incubated at 27oC, and after two days the following results were recorded;— 2, 3aC, 7a, 7aC, and 26bC showed definite signs of rotting of the rhizome tissues while 4C, 15, and 15C showed only slight rotting. As the time increased there was no change except that the rotting gradually increased and that the plug inoculated with 7aC showed a definite increasing pink colour.

As was done with the carrot inoculations, isolations were taken from the various rots produced and the letter "I" placed after the symbol of the original infecting organi m.

Greenhouse inoculations.

Van Hall (10) states that artificial infection can be easily produced by inoculating the pathogen into the base of the stem by means of needle pricks through the epidermis. He does not state on what medium the cultures were grown or how old they were when used for inoculation. He states, however, that after cultures have been carried on artificial media for a few months they lose their virulence and are unable to cause infection of the Iris tissues.

On December 5th., after the plants in the greenhouse had become well established, they were inoculated with two-day old cultures grown on Iris leaf infusion agar. The plants were inoculated by needle pricks at the base of the shoots and the placed under glass bell jars to keep them moist and at a fairly even temperature. After four days plants 15 and 19b showed slight traces of rotting around the points of inoculation. Two weeks after inoculation 2, 3a, 4CI, 4, 15, 15C, 15I, and 26bC showed nothing but a very slight rotting at the inoculated points. The infection from 19b had increased till one leaf had entirely rotted and the rhizome at the leaf base had just commenced to decay. Once the disease had reached this stage nothing further developed. An isolation was taken from the diseased leaf, labelled 19bG and used later for inoculation purposes.

Since practically no results had been obtained from the first series of inoculations, the writer decided to work only with the organisms that had caused the rotting of the sliced Iris rhizomes in the petri plates, as these would be the most likely disease producers.

On January 13th., seven plants were inoculated with one-day old been broth cultures of organisms laC, 4, 7a, 10, 15, 19bG, and 26b, and placed in the greenhouse under bell jars.. After two weeks no visible sign of infection had appeared, so the series was discarded and negative results recorded.

As no definite posite results had been obtained with either beef broth or agar cultures, it was thought advisable to use some other medium to see if better results could be obtained.

On February 8th., plants were inoculated with cultures 1a, 1aC, 1bC, Ca3, 4, 4C, 4C1, 7aI, 15, 5C, 19b, 26b, and 26bC, which had been prepared in the following way;—Original agar slope cultures were taken and transfers made from them to beef broth tubes. These tubes were incubated at 27°C for twenty four hours and then 1 c.c. of this bacterial suspension in the beef broth was transferred to 10 c.c. of a sterile 2% dextrose solution. The final culture was incubated for twenty -four hours and then used for the inoculation. The plants were inoculated by pouring the cultures at the base of the shoots and at the same time pricking the tissues with a sharp sterile needle. The plants thus ino-

culated were as before placed under bell jars in the greenhouse at a temperature ranging from 65°.70°F. (18°—22°C).

Eight days after inoculation, several plants, namely, 1bC, 7aI, 15C, and 19b showed definite signs of infection, the outer leaf blade in all cases being definitely watersoaked. At the end of twelve days no increase in infection was noted, except that 7aI had developed so as to exhibit definite symptoms of the disease, one shoot being entirely wilted. From an infected leaf of the above plant six re-isolations were taken and labelled 71-76. These re-isolations were made to agar slants, allowed to grow for one day at 27°C, then plates were poured and sngle colony pure cultures obtained. On February 24th., plants were inoculated with one-day old beef broth cultures of the organisms 71-76 inclusive in the same manner as previously described. Four days after inoculation definite symptoms were visible on plants 72 and 74. After four weeks the entire plants had become diseased. On March 3rd., seven days after inoculation, plants 73 and 75 also showed definite symptoms of the disease. Besides the usual watersoaking of the leaves, plant 73 showed a dark gray bacterial ooze exuding from the base of the infected shoot.

On March 10th., plants were again inoculated with twenty-four hour old beef broth cultures of organisms 1aC, 4, 10, 15C, 19b and 26b. After four day 19b showed definite symptoms of the disease. After seventeen days the plans had become entirely diseased and almost totally wilted. From young newlt infected leaves of this plant, five re-isolations were taken and numbered consey cutively from 191-195. The poured plate method was used to obtain pure-cultures, after which the organisms were used for re-inoculation purposes.

As a final test for the pathogenicity of the organisms, it was decided to try inoculations on plants which had been grown under absolutely sterile conditions. The sterile plants were obtained in the following manner; Iris plants about twelve inches high were taken from pots growing in the greenhouse and the soil entirely removed from the roots by washing in tap water and scrubbing with a small b ush. These plants were then washed in a 1-1000 mercuric chloride solution, after which they were thoroughly rinsed in two changes of sterile water. The pots used for transplantlng were four inch pots which had been thoroughly scrubbed and then soaked in mercuric chloride for ten minutes. As a soil, pure sand was used which had been previously autoclaved for two hours at eighteen pounds pressure. The sterile plants were placed in the sterilized pots which contained the sterilized sand and were then watered with sterile water, and kept till ready for inoculating.

The organisms used for inoculating were 721, 191, and 74. Agar slope cultures twenty-four hours old were used and the plants inoculated by means of needle pricks just below the surface of the sand. After inoculation the plants

were placed under bell jars and kept at 65o 70oF. The inoculations were made on April 4th., and at the end of one week all three plants showed definite disease symptoms.

Since good results had been obtained by using sterile plants for inoculation purposes, it was decided to complete Koch's rules of proof with organisms 7aI and 191 in this manner. On April 20th., the organisms were re-isolated from, the diseased plants.

The limited time available made it impossible for the writer to carry on extensive experiments to determine the natural atrium of infection under field conditions. However, in the many cases of inoculation that were tried by applying the inoculum to the base of the stem without wounding the tissues, no positive instances occurred. Smith (9) states that the most common means of infection is through wounds made in the host tissue by some mechanical means, such as insect punctures. Infections may also occur through lenticels, stomata, etc., but those through mechanical injuries are the most prevalent. The actual atrium of infection for the soft rot organism is not given, but it seems logical that the mechanical injuries at the bases of the shoots are the chief point for admitting the pathogen to the host.

Cultural Studies of the Organism.

The following account of the organism causing the soft rot of Iris is by no means exhaustive, but in the time available the writer has attempted to carry on sufficient experimental work to determine the identity of the pathogen.

The original collection of organisms was obtained from various sources during the summer of 1921 and kept growing on artificial media until used for inoculation experiments

As has already been described, these organisms were inoculated into slices of raw carrots and also slices of healthy Iris rhozomes. The organisms which proved pathogenic were then used for the plant inoculations and 7a1 and 19b were the only ones with which the writer was able to produce definite characteristic disease symptoms. 7aI was isolated from an infected rhizome slice after inoculation with 7a, which had been previously isolated from a diseased Iris plant at the College. 19b was a pure culture of *Bacillus carotovorus* obtained from Michigan Agricultural College.

Cultures of the pathogen were re-isolated from infected plants and then checked according to the chart compiled by the Society of American Bacteriologists.

In order to eliminate any error, Koch's rules of proof were carried out with plants grown under absolutely sterile conditions. From the infected plants

which had been rotted as a result of the inoculations with 72 and 191 isolations were made, namely, 721 and 1912. These isolations were grown, pure cultures made and with them another group of sterile plants was inoculated. Within a week characteristic symptoms had appeared in both cases. Again from these diseased plants isolations 7213 and 19122 were taken. No further inoculations were required because the organisms 72 and 191 had been "proved up" on sterile Iris plants.

The following will show a comparison of the organisms studied as compared with *Bacillus carotovorus*;

B. carotovorus ....B. 221.1113022
The writer's isolation.....B. 221.1113021

From the above numbers it appears that the pathogens studied have characters which resemble very closely those of *Bacillus carotovorus* (Jones). The actual resemblance, however, as will be seen later, is not as close as these group numbers appear to show.

Detailed Study of the Organisms.

In order to simplify the following discussion where no comparisons are made, it will be taken for granted that the organisms described are similar to *Bacillus carotovorus*.

Morphology.

The organisms studied were all rods with rounded ends, varying in length from 1.3 mu.—4 mu. and in width from.5 mu.-1 mu. Thisshows very littevariation from *B. carotovorus* which averages .8 mu. 2 mu. (Marshall (7). In all cases the organisms were actively motile by means of peritrichiate flagella. No endospores or capsules were found and the presence of pseudozoogloea or involution forms was not observed. The organisms are Gram negative and very susceptible to aqueous stains.

Broth.

Growth in beef peptone broth was extremely profuse, with only a slight pellicle and abundant sediment.

Agar Slant.

Growth was glistening, smooth, somewhat spreading and with a slight gray colour.

Agar Plate.

Small circular shining colonies were produced averaging in size about one half mm.

Gelatin Stab.

There is an extremely abundant surface as well as stab growth, which is beaded to filiform in appearance. Although the group numbers show liquefaction in all cases, there is a vast difference in the cultures. The 19b derivitives show fairly rapid liquefaction of the stratiform type starting the third day and becoming complete at the end of two weeks. The 7a1 derivitives show extremely slow liquefaction, never commencing before two weeks and at the end of five weeks showing only a slight napiform appearance. With *B. Cavotovorus* however, the liquefaction is extremely rapid, being complete within six days after inoculation.

Gelatin Plate Colonies.

Colonies are small and circular, and appear somewhat wrinkled when examined under the microscope.

Potato Plugs.

The growth is fairly abundant covering almost the entire the with a grayish white growth. The medium, however, was only very slightly grayed.

Miscellaneous Features.

All organisms showed abundant growth at 37°C but 27°C appears to be the optimum temperature. In no case was there growth on Cohn's solution, but Uschinshy' solution was favourable.

Milk.

The production of an acid curd with a slow peptonization of the casein was always characteristic.

Biochemical Features.

In every case there was a production of ammonia and a reductionof nitrates, also a slight production of indol.

In conclusion, although the writer's isolated organisms have practically the same group number as *Bacillus carotovorus*, they are not identical, as can be seen by the above characteristics, principally in relation to their liquefaction of gelatin. Although the derivatives of 19b liquefy gelatin, the action is not so rapid as in the case of *B. carotovorus*, nevertheless the liquefaction cannot be

disputed. In the derivatives of 7aI there is a greater difference in that the liquefaction is so slight as to be practically negligible. In all other characteristics, however, the differences are only of minor importance.

From the above study of the two pathogens causing the soft rot of Iris, it appears to the writer that the organisms, although not identical with B. carotovorus, do not vary sufficiently from it to become new species, therefore should be considered merely as slightly different varieties of the original organism described by Jones.

Smith (9) states that *B. oleraceae* (Harrison), *B. omnivorus* (Van Hall), and *B. apivorus* (Wormold) are apparently identical with *B. carotovorus* (Jones), and since the writer proved the organism causing soft rot of Iris to be a variety of *B. carotovorus*, it therefore appears that the organism causing the disease in this country is similar to that causing the disease in Europe.

Pathological Histology.

The material for this study was taken from various parts of the plant, both leaf and rhizome, in different stages of infection. Both naturally and artificially inoculated plants were used. The samples were killed and prepared in the usual way for microtome sectioning. The sections were in most cases stained with carbol fuchsin, but occasionally Delafield's haema toxylin was used.

Pathological Effect on the Rhizome.

The cells of healthy rhizome tissue are very uniform in size and shape. The difference in size of the cells in respective sections may be due to the fact that they are taken from plants of different varieties or from different parts of the rhizome. The cells contain large numbers of starch grains, the protoplasm being almost entirely hidden except for the very distinct nuclei.

The progress of the disease in the rhizome is extremely rapid and, therefore, the writer was unable to obtain good specimens of the primary effect of the pathogen upon the host tissues. The cell walls gradually become broken down, and the cell shape is far less definite than in the healthy tissue. The destruction of the middle lameilae and thus the separation of the cells from one another can be seen in many places. In the primary infected tissues it can also be noted that the cell contents, both starch and protoplasmic commence to disintegrate. The starch grains are fewer in number than in the healthy tissues and less regularly placed. Plasmolysis also occurs combined with a slight enlargement of the nuclei.

As the disease progresses the cell contents gradually become more plasmolyzed and disintegrated until they have practically disappeared. The last part of the cell contents to disintegrate is the nucleus, but as the disease progresses, this also becomes broken down and the whole cell contents, resemble an irre-

gular, loose, granular mass within the cell wall. Later the cell wall disintegrates until the entire tissue becomes a broken down mass, which will scarcely hold together.

The absence of bacteria in the primary stages of the disease leads the writer to believe that there is a toxine or enzyme produced by the invading bacteria which is able to cause the disintegrative effet on the host at some distance from the cells occupied by the bacteria themselves.

In many cases, while examining slides of diseased lissues, the writer observed vascular bundles which were more or less filled with a golden brown, very finely granular material. Whether or not this was due to the effect of the invading organism the writer is unable to state definitely, because all vascular bundles of diseased parts did not contain these deposits. The fact remains, however, that in no case were there any such deposits observed in the healthy rhizome tissues.

Pathological Histology of Leaves.

A definite outline of the cells and a uniformity of the structure and arrangement is typical of the healthy tissues.

The first noticeable effect of the pathogen on the leaves is a dissolution of the middle lamellae of the cells, thus allowing them to separate from one another. As the disease progresses, the cell contents become broken down. This disintegration continues fairly rapidly until the entire leaf becomes broken down and is held together only by fragments of the vascular bundles.

When the leaf tissues become watersoaked, the epidermis loosens from the remainder of the leaf tissue and can easily be removed.

The rotting is not confined to the leaf parenchyma, for the vascular system is also attacked to a considerable extent. Even although the vascular tissue is subject to the destructive influence of the pathogen, it is not so totally susceptible and does not become entirely disintegrated even in the final stages of the disease.

As was the case with the rhizome tissues, most of the damage or at least a large part of it appears to be caused by a toxic substance produced by the invading bacteria, and not by the actual presence of the pathogenic organism. As the writer's time was necessarily limited, no experiments could be carried out to prove this point. Van Hall (10, however, investigated it rather thoroughly. He took liquid cultures of the pathogen he had isolated, namely *B. omnivorus*, and filtered it so as to remove all the bacteria. The filtrate thus obtained which contained no living organisms, was used for inoculating certain Iris plants which later developed light symptoms of the disease.

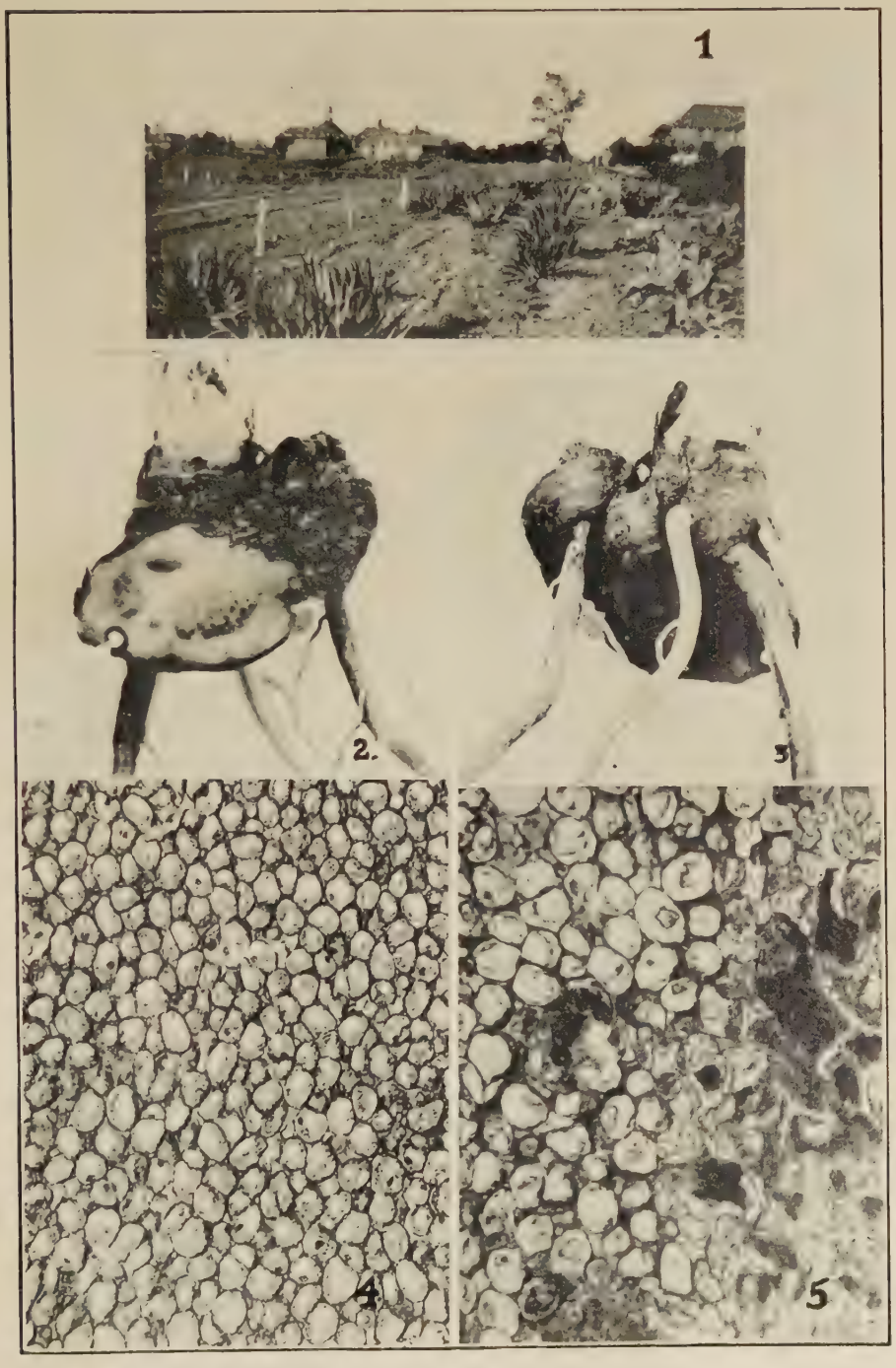
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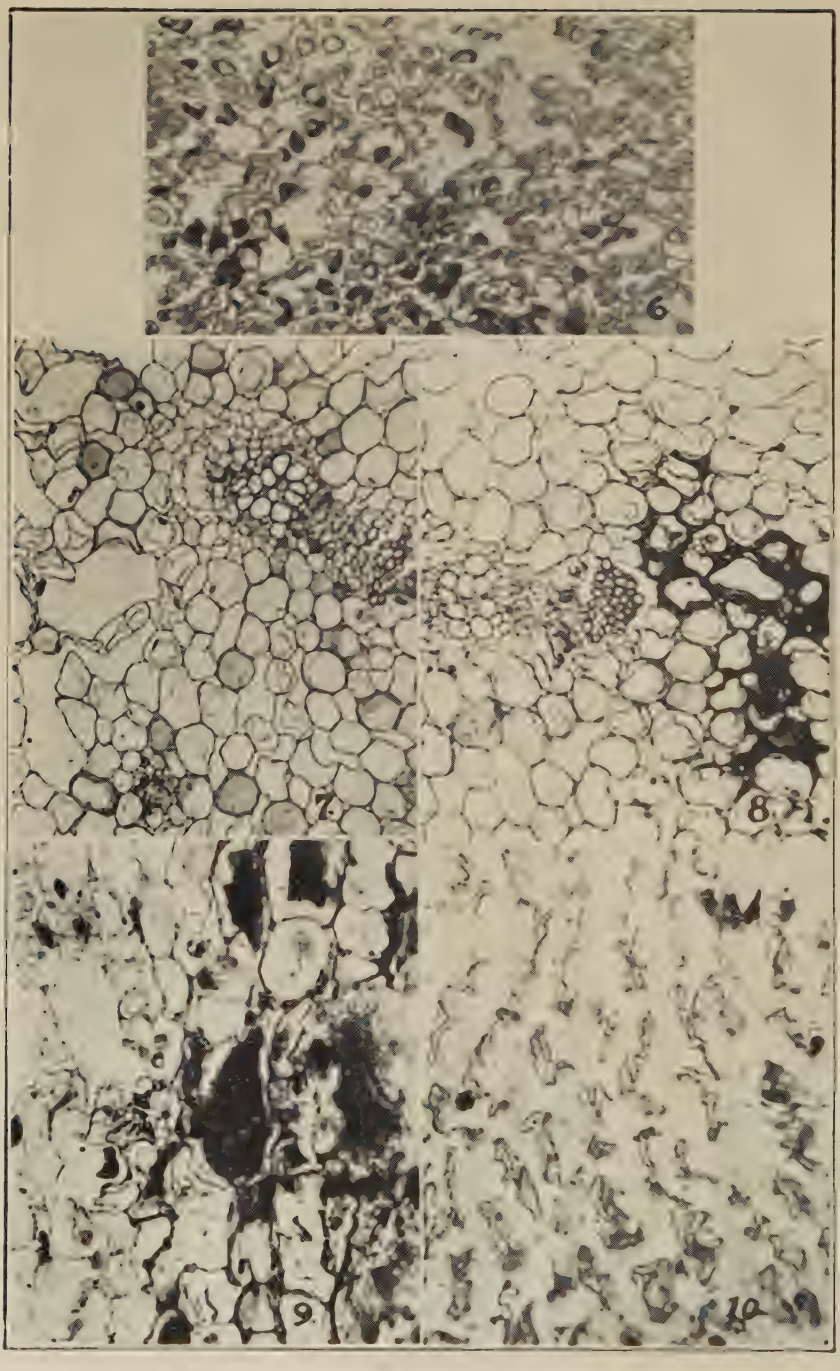
PLATE VI



11.
12.
13

The above described pathological histology differs from that given by Van Hall (10) in two main points;—First, he states that the starch grains are not destroyed by the invasion of the bacteria, and second that the bacteria are unable to enter the cells, that is, they are entirely intercellular. In egard to the first point, in all the diseased sections that were examined by the writer, in not a single case were the starch grains found to be intact. With regard to the second difference, the writer was able to obtain photomicrograph which definitely showed the bacteria in the cells. Whether the bacteria penetrated the wall and thus entered the lumen of the cell, or whether they entered after the wall was ruptured, the writer is not able to state. The bacteria may not enter the cell till after the wall is ruptured, but in any case it is the toxine (Van Hall (10) produced by the invading pathogen that causes the breaking down of the wall; and even if the organisms do not enter the lumen till the wall has been ruptured, the fact remains that they do enter the cell, and are, therefore not strictly intercellular.

Summary.

1. Bacterial rhizome rot of Iris is increasing in importance in this part of the country.
2. The organisms causing soft rots are parasitic on a wide range of plants.
3. The complete geographical distribution of bacterial soft rot of Iris is not known, but the disease is probably wide spread.
4. This disease is economically important on account of its destructiveness to large numbers of valuable Iris plants.
5. The disease is a typical soft rot destroying the rhizome parts attacked as well as the foliage.
6. Thirty-six organisms were isolated from various sources and different inoculation tests carried out which resulted in the obtaining of typically diseased plants by inoculation with two of the organisms used.
7. The two pathogens finally "proved up" by the writer react on various media in a similar manner to *B. Carotovorus* and are believed to be forms of that species.
8. Smith (9) states that *B. Oleraceae, B. omnivorus* and *B. Apivorus* are apparently identical with*B. Carotovorus.* The writers' work shows that the disease in Quebec is caused by a form of *B. Carotovorus.* If the view of Smith is correct, it appears that the disease in Quebec and in Europe is caused by similar organisms.
9. The pathogen destroys the host by a dissolution of the middle lamellae of the cells, a gradual destruction of the cell contents, and finally a total disintegration of the diseased tissues.

This article is an abridgment of a thesis taken under Dr. B. T. Dickson in the Department of Botany, Macdonald College, and submitted to the Graduate School of McGill University in partial fulfilment of the requirements for the degree of M. Sc.

The writer wishes to acknowledge his appreciation to Dr. Dickson for helpful suggestions and constructive criticism, to Dr. Hood of Macdonald College and Dr. L.-R. Jones of Wisconsin for cultures which they supplied and to Mr. J. P. Spittall for his translation of German references.

Contribution No. 20 Dept. of Botany, Macdonald College, Que.

DESCRIPTION OF PLATES.

Plate V.

FIG. 1.—The Iris plot at Macdonald College, showing misses due to plants having been killed by the disease.

FIG. 2.—The cut surface of an Iris rhizome, showing diseased and healthy tissue.

FIG. 3.—Reverse side of Fig. 2 showing very little differentiation except the collapsing of the root on the diseased part.

FIG. 4.—Photomicrograph of cross section of healthy rhizome tissue showing the starch grains intact.

FIG. 5.—Cross section of diseased rhizome tissue showing the lack of starch grains and also the bacteria within the cells.

Plate VI.

FIG. 6.—The final stage in the disintegration of a diseased rhizome.

FIG. 7.—Section through a healthy leaf.

FIG. 8.—Section of a diseased leaf showing the death of the tissues due to the invasion of the pathogen.

FIG. 9.—Diseased leaf tissue showing disorganization of cells and presence of bacteria.

FIG. 10.—The final stage in the disintegration of the leaf tissue

Plate VII.

FIG. 11.—The complete death of a plant caused by the artificial inoculation with *B. Carotovorus*.

FIG. 12.—One collapsed shoot of an infected plant showing the typical water-soaking, a characteristic early symptom.

FIG. 13.—Here is shown the complete collapsing and typical watersoaking of a plant inoculated while growing under absolutely sterile conditions.

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CORRIGENDUM.

Prof. B. T. Dickson.

On page 82 of the Fourteenth Annual Report of the Quebec Society for the Protection of Plants (1921-22) in an article concerning Potato Canker wherein is given a list of countries from which the disease has been reported, France is included.

In a letter dated February 27th, 1923, Dr. Etienne Foex, Director of the Station of Vegetable Pathology, Paris, France, states that this disease has never been found in France in spite of careful search. That it does not occur in Italy is also the belief of Dr. Foex.

I am glad to insert this corrigendum in the Fifteenth Annual Report, and trust that recipients will insert it alongside page 82 of the Fourteenth Report.

FRENCH AND ENGLISH NAMES FOR THE COMMON INSECTS OF QUEBEC.

By G. Beaulieu.

(Printed by permission of Mr. A. Gibson, Dominion Entomologist).

A

Apple aphis	Puceron du pommier
Apple curculio	Charançon de la pomme
Apple leaf skeletonizer	Pyrale de la feuille du pommier
Asparagus beetle	Criocère de l'asperge
Apple leaf hopper	Cicadelle du pommier
Armyworm	Légionnaire
Ambrosia beetle	Scolyte perceur
Ash gray blister beetle	Cantharide gris cendre
Alfalfa leaf weevil	Charançon de l'alfalfa
American cockroach	Coquerelle des caves
Apple maggot	Larve de la pomme
Angoumis grain moth	Mite angoumoise du grain
Apple twig beetle	Scolyte du pommier

B

Bean weevil	Bruche couverte
Black peach aphis	Puceron noir de la pêche
Black cutworm	Ver gris noir
Bronze birch borer	Perceur doré du bouleau
Bean leaf beetle	Chrisomêle de la feuille de haricot
Bed bug	Punaise des lits
Buffalo tree hopper	Cérèse de Buffalo
Beet leaf hopper	Cicadelle de la betterave
Black blister beetle	Cantharide noire
Brown-tail moth	Bombyx cul brun
Bee moth	Teigne des ruches
Birch sawfly	Mouche à scie du bouleau
Blackberry soft scale	Kermès de la ronce
Bronzed cutworm	Ver gris bronze
Black vine weevil	Charançon noir de la vigne
Bag worms	Chenilles à besace
Black scale	Kermès noir
Book louse	Atropos des livres
Bud moth	Ver du bourgeon
Bronze flea beetle	Puce de terre
Birch leaf mining sawfly	Mouche minière des feuilles du bouleau.
Black violet aphis	Puceron noir de la violette
Birch skeletonizer	Bucculatrix du bouleau

C

Cabbage aphis	Puceron du navet
Cabbage looper	Noctuelle des choux
Carpet beetle	Rongeur des tapis
Cherry scale	Kermès du cerisier
Corn root aphis	Puceron de la racine du maïs
Currant borer	Aegie du groseillier
Chestnut weevil	Charançon de la noisette
Clover mite	Mite du trèfle
Cowpea weevil	Bruche de chine
Catalpa sphinx	Sphinx catalpa
Cigar case bearer	Chenille porte case du pommier
Codling moth	Pyrale de la pomme
Cranberry looper	Arpenteuse de la caneberge
Currant fruit fly	Ver à groseille à grappes
Cherry leaf beetle	Galerucelle du cerisier
Clover root borer	Rongeur de la racine du trèfle
Colorado potato beetle	Chrysomèle de la pomme de terre
Cherry aphis	Puceron du cerisier
Clover cutworm	Mamestre du trèfle
Currant aphis	Puceron du raisin
Cabbage maggot	Vers des choux
Cottony maple scale	Kermès floconneux de l'érable
Carrot rust fly	Mouche de la carotte
Cabbage plusia	Plusia du choux
Cabbage worm	Chenille du choux
Cabbage pinionea	Pionea du choux
Cherry fruit maggot	Mouche du cerisier
Cecropia moth	Attaque cecropia
Carpet moth	Mite des tapis
Cankerworm	A penteuse du pommier
Clover weevil	Brûche du trèfle
Cherry or pear slug	Némate (petite livrée)
Clover seed midge	Mouche de la graine du trèfle

D

Diamond back moth	Teigne des choux
Destructive pea aphis	Puceron destructeur du pois

E

Eight spotted forester	Alypie à huit taches
European fruit scale	Kermès coquille à l'huître
Euonymus scale	Kermès euonymes
Elm borer	Saperde de l'orme
Elm woolly aphis	Puceron lanigère
Eye spotted bud moth	Pique-bouton ocellé

F

Fall webworm	Chenille à toile d'automne
Fall cankerworm	Arpenteuse de l'automne
Fuller's rose beetle	Charançon de la rose

Flat headed apple tree borer	Ver rongeur du pommier
Florida red scale	Kermès rouge de Floride
Fern scale	Kermès des fougères
Florida wax scale	Kermès cire de Floride
Fall armyworm	Légionnaire d'automne
Fir sawfly	Mouche à scie du sapin
Forest tent caterpillar	Livrée des forêts
Five spotted hawk moth	Sphinx à cinq taches
Fungus gnat	Mycetophile du champignon

G

Grape scale	Kermès de la vigne
Greedy scale	Kermès rapace
Greenhouse white fly	Aleurodes des serres
Green june beetle	Hanneton vert
Grass thrips	Thrips commune de l'herbe
Green striped maple worm	Ver à raies vertes de l'érable
Granary weevil	Charançon des greniers
Grape curculio	Charançon de la vigne
Green house leaf roller	Tordeuse des feuilles des serres
Gray blister beetle	Cantharide grise
Glassy cutworm	Ver gris vitraux
Grape flea beetle	Altise de la vigne
Glover's scale	Kermès de Glover
Grape phylloxera	Phylloxera de la vigne
Gipsy moth	Bombyx disparate
Green house leaf tyer	Lieuse de feuille des serres
Green clover weevil	Charançon vert du trèfle
Grapevine aphis	Puceron des vignobles
Grain aphis	Puceron du grain
Grape leaf hopper	Cicadelle de la vigne
Green fruit wo m	Ver des fruits verts

H

Howard's scale	Kermès de Howard
Honey bee	Abeille
Horse bot fly	Gastrophile du cheval
House cricket	Grillon domestique
Horn fly	Mouche des cornes
Harlequin cabbage bug	Punaise des choux
Hessian fly	Mouche de hesse
House fly	Mouche des maisons
Hop aphis	Puceron du houblon
Hemispherical scale	Kermès hémisphérique

I

Io moth	Noctuelle Io
Imported cabbage worm	Ver exotique des choux
Impor ed currant worm	Ver exotique du rainin

J	
June beetle	Hanneton-Larve du hanneton
L	
Larch case bearer	Porte case du mélèze
Larder beetle	Dermestre du lard
Lesser apple worm	Petit ver de la pomme
Lesser house fly	Petite mouche des maisons
Latrine fly	Mouche des latrines
Lesser migratory locust	Petite locuste voyageuse
Large clover weevil	Gros charançon du trèfle
Large larch sawfly	Mouche à scie du mélèze
M	
Melon caterpillar	Chenille du melon
Margined blister beetle	Cantharide marginée
Mediterranean flour moth	Papillon gris de la farine
Magnolia scale	Kermès du magnolia
Maple leaf cutter	Chenille de la feuille de l'érable
Mealy bug	Faux kermès des serres
N	
Negro bug	Punaise noire
Northern mole cricket	Hanneton du cerisier
Narcissus fly	Mouche du narcisse
O	
Oblique banded leaf roller	Cigareuse à bande obiqlue
Oyster shell scale	Kermès à coquille d'huître
Onion maggot	Ver de l'oignon
Onion thrips	Thrips de l'oignon
P	
Potato tuber moth	Teigne de la pomme de terre
Q	
Quince curculio	Charançon de l'aubépine
R	
Rose scale	Kermès de la rose
Rice weevil	Charançon du riz
Red backed cutworm	Ver gris à dos rouge
Rocky Mountain spotted fever tick	Teigne à fièvre des Mts Rocheuses
Rose sawfly	Nématode du rosier
Red turnip beetle	Ba beau rouge du navet
Raspberry webworm	Fausse chenille à tente du framboisier
Raspberry awfly	Nématode du framboisier
Red legged locust	Sauterelle commune
Rose chaffer	Scarabie du rosier
Raspberry cane borer	Perce bois du framboisier
Red humped apple caterpillar	Charançon à bosse rouge du pommier
Round headed apple tree borer	Saperde du pommier
S	
San José scale	Kermès San José
Sinuate pear tree borer	Agile du poirier
Squash bug	Punaise de la courge
Strawberry crown moth	Aegerie du fraisier

Strawberry leaf roller	Ancylis rongeur de feuilles du fraisier
Strawberry weevil	Charançon du fraisier
Silkworms	Bombyx du murier
Scurfy scale	Kermès teigne
Spruce gall louse	Kermès de l'épinette
Striped cucumber beetle	Chrysomèle du concombre
Strawberry flea beetle	Altise de la fraise
Sugar cane beetle	Barbeau de la canne à sucre
Sheep maggot	Lucille du mouton
Spotted cutworm	Ver gris tacheté
Spotted paria	Paria tacheté
Stable fly	Mouche des étables
Squash lady beetle	Coccinelle boréale
Striped blister beetle	Cantharide barrée
Strawberry crown borer	Perce collet fraisier
Spruce budworm	Ver du bourgeon de l'épinette
Shot borer	Xylebore
Spring tail (Collembola)	Colembale

T

Ticks	Teignes
Tobacco flea beetle	Altise du tabac
Tarnished plant bug	Punaise terne
Tent caterpillar	Livrée
Two-striped locust	Locuste à deux bandes
Tomato worm	Ver de la tomate
Turkey gnat	Mouche noire meridionale

V

Virginian anista	Anistade Virginie
Variable cutworm	Ver gris variable
Variegated cutworm	Ver gris panaché

W

Willow leaf beetle	Galerucelle du saule
Wheat stem maggot	Mouche à scie du chaume de blé
White line sphinx	Sphinx à ligne blanche
Walnut sphinx	Sphinx du noyer
White cedar twig borer	Perce rameau du cèdre blanc
West Indian peach scale	Kermès de la pêche des Antilles
Walnut scale	Kermès du noyer
Warble fly	Hypoderme rayée-oestre du bœuf
White marked Tussock moth	Hemerocampe marquée de blanc
Wheat stem maggot	Ver du chaume de blé
Woolly apple aphis	Puceron lanigère
Weevil	Curculion or Charançon

Y

Yellow headed cranberry worm	Acleris de la canneberge

Z

Zebra caterpillar	Chenille zébrée

ABSTRACTS OF CANADIAN PLANT PATHOLOGICAL LITERATURE.

A. W. McCallum.

The abstracts and references given herewith include the papers on plant pathology published in Canada during 1922.

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Mention is made of leaf scorch of strawberry caused by "Mollisia earlianna (E and E) Sacc., potato diseases, and the dry formaldehyde treatment for oat smut.

Anonymous. Interim Report. Ann. Rept. Division of Botany, Dom. Exp. Farms for 1920—1921. 1—108. 17 fig. 1921.—This report covers a period of five years during which no data was published owing to economic reasons. Attention is called to sections on the potato inspection service, forest pathology, investigations on common scab of potato, leaf curl and mosaic of raspberries, nature of susceptibility, and cereal rusts. Progress upon the various experiments being carried on at the field laboratories is reported.

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Blair, R. J. Chemical Wood Pulp is attacked by Molds. 14th Ann. Rept Que. Soc. Prot. Plants for 1921—1922: 39—41. Fig. 1—3. 1922.

Dickson, B. T. Diseases of the Potato. Sci. Agric. 2: 202-206. Fig. 10. 1922.—A recapitulation of present knowledge concerning canker, leak, and late blight.

*Dickson, B. T. Diseases of the Potato. Sci. Agric. 2: 234-236. Fig. 11-12. 1922.—Notes on a stalk disease caused by "Sclerotinia sp." and on little potato caused by "Corticium vagum "*B. *and C. var. "solani" Burt.*

Dickson, B. T. Diseases of the Potato. Sci. Agric. 2: 310-312. 1922.—Early blight, fusariose, common scab, skin spot, and silver scurf are treated briefly.

Dickson, B. T. Diseases of the Potato. Sci. Agric. 2: 325-327. Fig. 13-14 1922.—Notes on dry rot, net necrosis, and black dot disease. This latter is apparently due to "Vermicularia varians."

Dickson, B. T. Diseases of the Potato. Sci. Agric. 2: 417-419. 1922.—Brief notes on various physiological troubles.

Dickson, B. T. Plant diseases of 1921 in Quebec. 14th Ann. Rept. Que. Soc. Prot. Plants for 1921—1922: 52-58 Fig. 1-8. 1922.

Dickson, B. T Diseases of the Potato. 14th Ann. Rept. Que. Soc. Prot. Plants for 1922-1922: 67-105. Fig. 1-12. 1922.

Dickson, B. T. Studies Concerning Mosaic Diseases. Macdonald Coll. Tech. Bull. No. 1-125. Pl. 1-2: 1922—A very comprehensive list of plants known to be affected by mosaic is given The pathological histology of a large number of various species of plants affected with mosaic has been studied and numerous histological features are found to be common to all The effect of coloured light on tobacco mosaic and the effect of coloured light, sunlight, darkness, and freezing on the expressed juice of tobacco mosaic plants was studied. Mosaic was found to be transmitted by aphids and seed inheritance was established for several species.

Eastham, J. W. Report of Provincial Plant Pathologist, Vancouver. 16th Ann. Rept. B. C. Dept. Agric. for 1921: 64-69. 1922.—Three diseases not noticed previously were observed during the year. These were clover wilt "(Sclerotinia trifoliorum)," buck-eye rot of tomato ("Phytophthora terrestria)", and blister rust of white pine ("Cronartium ribicola).

Faull, J. H. Forest Pathology: In Report of Forestry Branch, 1921. Ann. Rept. Min. Lands and Forests, Ont. for 1910-1921: 259-266. Fig. 1-4. 1922. —Observations were continued upon white pine needle blight in the Temagami Forest Reserve and these confirmed previous conclusions which had been drawn in regard to this disease. The reddening of the leaves is due to the death of the absorbing roots which, in turn, is ascribed to a drying-out process that occurs in shallow soils in periods of drought.. It is probable that other tree species are affected in a similar manner.—A general investigation of butt rots of conifers is being carried on. In this work a root and butt rot of spruce, hemlock, and white pine has been observed for the first time. With this decay, which is of the type caused by Trametes pini, a stalked polypore, 'Polyporus tomentosus," is constantly associated. A preliminary account of the true tinder fungus "(Fomes fomentarious)" is given in which it is recorded that instead of causing a sap rot as commonly supposed this fungus seems invariably to commence work in the heartwood of its hosts--Poplar canker ("Dothichiza populea)" has been observed near Toronto causing much damage to a plantation of Lombardy poplars.

Faull, J. H. Forest Pathology in Relation to Forest Conservation. 14th Ann. Rept. Que. Soc. Prot. Plants for 1921-1922l 14-22. Fig. 1-5. 1922.

Grisdale, J.-H. Report of the Acting Dominion Botanist. Ann. Rept. Dom. Exp. Farms for 1918-1919\ 57-61 1920.

Gussow, H. T. Report of the Dominion Botanist. Ann. Rept. Div. of Bot. any, Dom. Exp. Farms for 1921-1922: 1-73 3 Fig 1922—The annual report of the Division of Botany containing accounts of the various phases of investigative work carried on at the central and field laboratories Attention is drawn to the sections dealing with potato inspection and certification, forest pathology, leaf curl and mosaic of raspberries, and cereal rusts.

Jackson, V. W., J. F. Higham and F. W. Bradbrooke. Control of Tagged Wheat. Man. Agric. Ext. News 2\ 2. 1922.

Lachaine, O. W. Sclerotial Disease of the Potato. 14th Ann. Rept. Que. Soc. Prot Plants for 1921-1922\ 105-109. Fig. 1-6 1922

Major, T.-G. An Alternaria Disease of Polypodium. 14th Ann. Rept. Que. Soc. Prot. Plants for 1921-1922\ 59-61. 1 fig. 1922.—A new species of "Alternaria (A. polypodii) occurring on greenhouse ferns is described and its pathogenicity demonstrated.

McCallum, A. W. Abstracts of Canadian Plant Pathological Literature. 14th Ann. Rept. Que. Soc. Prot. Plants for 1921-1922: 110-115 1922.

Newton, Margaret. Studies in Wheat Stem Rust. "(Puccinia Graminis Tritici) Trans. Roy. Soc. Can. (3rd series, section 5). 16\ 153-210. Text fig. 1-3, pl. 1-6 1922—Fourteen biologic forms of wheat stem rust have been shown to be present in Western Canada and their distribution is provisionally given. All of these forms also occur in the United States—Invariably, infection was found to occur by way of the stomata after an appressorium had been formed The susceptible host adjusts itself readily to the presence of the parasite but in the resistant species the hyphae sent out by the sub-stomatal vesicles soon die The suggestion is made that the failure of the fungus to establish itself in a resistant plant may be due to starvation caused by the death of the local host cells.

Tice, C. Seed Potato Inspection and Certification in British Columbia. Sci. Agric. 2\ 249-251. 1922.

White, E. W Apple Tree Anthracnose or Black Spot Canker Control. Sci. Agric. 2: 186-191. Fig. 1-3. 1922.—The results of co-operative experiments extending over a number of years indicate that anthracnose which is very prevalent and destructive in the coastal region of British Columbia can be controlled by systematic spraying with Bordeaux.

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ELEVENTH ANNUAL REPORT

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Quebec Society for the Protection of Plants from Insects and Fungous Diseases

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